AR-010-467

Framing: Supporting Change for a System as an External Activity

John O'Neill

DSTO-RR-0127

APPROVED FOR PUBLIC RELEASE

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

Framing: Supporting Change for a System as an External Activity

John O'Neill

Information Technology Division
Electronics and Surveillance Research Laboratory

DSTO-RR-0127

ABSTRACT

This thesis demonstrates how computer systems can aid people in organisations conceiving situations that change an organisation's behaviour. A theory of framing is proposed that describes how people in organisations use intents to recognise real-world events that are relevant to an organisation, conceive situations, and through a negotiation process construct new intents that can change an organisation's behaviour. A system called FRAMER was developed to demonstrate how the theory of framing can be used to aid people framing situations that change an organisation's behaviour. Two case studies are used to illustrate the utility of the theory of framing: one drawn from the strategic and operational planning required for an actual ADF operation, the second drawn from some of DSTO's internal planning.

RELEASE LIMITATION

Approved for public release

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

Published by

DSTO Electronics and Surveillance Research Laboratory
PO Box 1500
Salisbury South Australia 5108 Australia

Telephone: (08) 8259 5555
Fax: (08) 8259 6567

AR-010-~~355~~ 467
March 1998

APPROVED FOR PUBLIC RELEASE

Framing: Supporting Change for a System as an External Activity

Executive Summary

This thesis demonstrates how computer systems can aid people in organisations conceiving situations that change an organisation's behaviour. The activity of changing an organisation's behaviour is external to the organisation, and involves negotiation with other institutions. The boundary objects being constructed and negotiated during this activity are intents. The intents of an organisation describe how the organisation is expected to behave by other institutions, and describe the relationships between the activities of different institutions and activity systems. These intents define a space for designing an organisation's structure and activity systems.

A theory of framing is proposed that describes how people in organisations use intents to recognise real-world events that are relevant to an organisation, conceive situations, and construct new intents that can change an organisation's behaviour. Descriptions of intents are used as generative metaphors for constructing the initial framing knowledge representations for framing the situation. The framing activity may involve redescribing concepts in the framing knowledge representation, constructing new intents that are used to coordinate activities across activity systems and institutions, and sometimes constructing new intents that change the behaviour of the organisation.

A new knowledge representation technique called descriptive networks is developed to cope with the ephemeral nature of concept descriptions and the requirements of constructing framing knowledge representations. Sixteen framing elements are defined to support the theory of framing and the construction of framing knowledge representations. A system called FRAMER was developed to demonstrate how the theory of framing, the descriptive networks, and the sixteen framing elements can be used to aid people framing situations that change an organisation's behaviour.

Two real-world case studies are used to illustrate the utility of the theory of framing, the descriptive networks, the sixteen framing elements, and FRAMER. The first case study is based on the Australian Defence Force's participation in providing humanitarian disaster relief aid to the people of Rabaul after volcanic eruptions. The second case study is based on work performed in the Defence Science and Technology Organisation (DSTO) defining the role of the DSTO C3 Research Centre in a new program of work called Takari.

The major finding of this thesis is that reasoning about goals within an organisation is inadequate for understanding how an organisation's behaviour may change. Changing an organisation's behaviour is an externally negotiated activity to the organisation. The output of these negotiations are framing knowledge representations which describe how other institutions expect an organisation to behave.

Authors

John O'Neill
Information Technology Division

John O'Neill is a Professional Officer Class 2 within the Information Architectures Group. He is leading a section responsible for researching C2 social and organisational architectures. This document is John's PhD thesis which was written "on the job" at DSTO whilst conducting research into strategic and operational C2 systems for the ADF.

Contents

List of Figures

1. Introduction

Daring as it is to investigate the unknown, even more so is it to question the known -- Kaspar

1.1 Background

The subject of this thesis is how people in organisations conceive situations that change an organisation's behaviour. Consider how a military organisation's behaviour must change with the advent of peacekeeping operations. Instead of "defeating the enemy", military organisations conducting peacekeeping operations must now engage in the activities associated with "nation-building". These activities include repairing water and sewerage systems, building bridges, collecting weapons, and distributing food. A military organisation must change the way it "thinks" in peacekeeping situations. There is no "enemy", instead there are continually shifting coalitions between different social groupings, each with their own political objectives. Military organisations are no longer "commanders", instead they must collaborate with institutions such as foreign aid agencies with which they have historically rarely interacted.

Redefining an organisation's behaviour is an activity that is external to the organisation. An organisation cannot unilaterally change its behaviour and continue being successful. Instead, it must negotiate these changes with other institutions including its customers, suppliers and shareholders, and these changes will be constrained by the extant political, social, economic, legal and diplomatic frameworks. For example, a military organisation cannot simply decide to conduct a peacekeeping operation. Instead, it must collaborate with its government, other government departments, foreign aid agencies, and the different political interests in the nation in which peacekeeping will be conducted. These collaborations occur in a framework of social, economic, political, diplomatic and legal constraints. It could be argued that in a democracy the military does not legally act without the government's authorisation. However, this argument fails to recognise that the government itself is bound by

political, legal, diplomatic, social and economic constraints, and that the judgement of the government's actions by the voters and media will determine the lifespan of a particular government.

The result of externally negotiating an organisation's behaviour is a set of statements that describe how other institutions expect an organisation to behave. These statements have been characterised as problem-setting (Schön 1993), defining a common objective problem (Berger and Luckman 1969), and goal-finding (Rittel and Webber 1973). In Godel's (1931) terms, these statements are the basic, given assumptions that cannot be proven true or false *within a system.*

There are two alternative views concerning how people conceive situations: the rationalistic "knowledge-based systems" approach; and the situated action approach. Neither of these approaches provide any explanation as to how the externally negotiated set of statements are constructed and how these statements are used to define new activity systems and redefine the nature of existing activity systems. In the rationalistic "knowledge-based systems" approach, people classify events in the real-world environment in terms of pre-defined, well-structured problems (Simon 1973) and then navigate through problem-spaces to solve the problem (Newell and Simon 1972). In contrast, the situated action approach focuses on describing how problematic situations arise during human activity and the improvisatory behaviour that emerges as people learn by doing within an existing activity system (Suchman 1987; Lave 1988; Chaiklin and Lave 1993; Lave 1993; Clancey 1997).

1.2 The Ethos of an Organisation, Intents, and Framing

The central concepts in this thesis for describing how people in organisations conceive situations that change an organisation's behaviour are: the ethos of the organisation, intents, and framing.

The *ethos of an organisation* may be articulated as a set of values, responsibilities, constraints and intents. It defines how the organisation is expected to behave and the organisation's relationship to other institutions by political, economic, social, and regulatory factors. For example, the ADF's ethos includes that it has the intent to "defend Australia's national interests", that it has responsibilities to aid people in the

south-west Pacific in disaster situations, and that it is constrained to only performing actions that maintain a military capability in peacetime (Strategic-Review 1993).

Intents were defined by the Scholastics in the Middle Ages as something "that points outside itself to something else" (Audi 1995, p381). This notion of intents is illustrated by comparing the descriptions of the purpose of two logistic organisations who conduct the same type of business. The first logistic organisation described their purpose as "a quality logistic organisation". The logistic organisation could rationally define what this purpose means without reference to any other institution and is similar to the concept of intentions used in agent-oriented research (Bratman 1987). The second logistic organisation described their purpose as "quality logistic support to flying operations". Defining what this purpose means requires negotiation with the flying organisation to determine what the flying requirements are, what the logistic requirements are, and what it means to logistically support a flying organisation. The relationship between the logistic and flying organisations will always be subject to renegotiation as events in the real-world environment unfold. Therefore, any description of this purpose will always be incomplete and will "point outside itself" to the relationship between the organisations. In these terms, the purpose for the second logistic organisation is an intent.

Four types of intents are defined in this thesis: generic intents, core intents, situation-specific intents, and reasoning intents. *Generic intents* represent the purpose of the organisation and names the different types of situations in which the organisation expects to be involved. For example, the generic intent hierarchy for the ADF is shown in Figure 1.1. *Core intents* represent instruments that are used under direction. For example, the ADF is an instrument that the Australian government directs to achieve national intents. Similarly, capabilities in the ADF, such as strike and air transport, are instruments that are directed by ADF personnel to achieve the situation-specific intent.

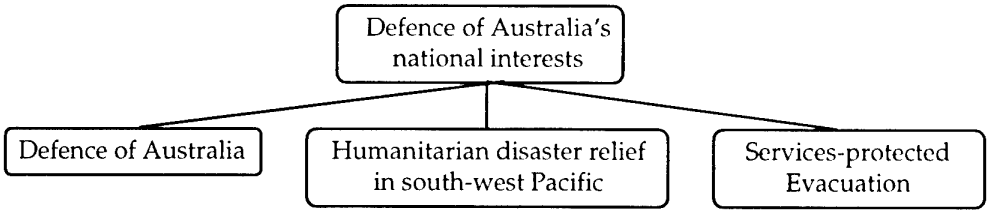

Figure 1.1 A generic intent hierarchy

Situation-specific intents situate generic intents and core intents by describing the purpose of an organisation in a situation. Constructing a situation-specific intent involves negotiating with other institutions and may involve changing the ethos of an organisation. Situation-specific intents are manifested as strategies. The relationship between generic intents, situation-specific intents and strategies is shown in Figure 1.2. *Reasoning intents* represent the purpose of the activities performed, and models constructed, during a situation in relation to other activities being performed. Reasoning intents are used to ensure that optimisation within a local activity system does not de-optimise the organisation's other activity systems, or the situations in which the organisation is acting. For example, optimising the use of transport aircraft cannot be conducted in isolation, instead this scheduling activity must be done in parallel with other activity systems such as scheduling landing slots at airfields, scheduling road transport, and scheduling aircrew availability.

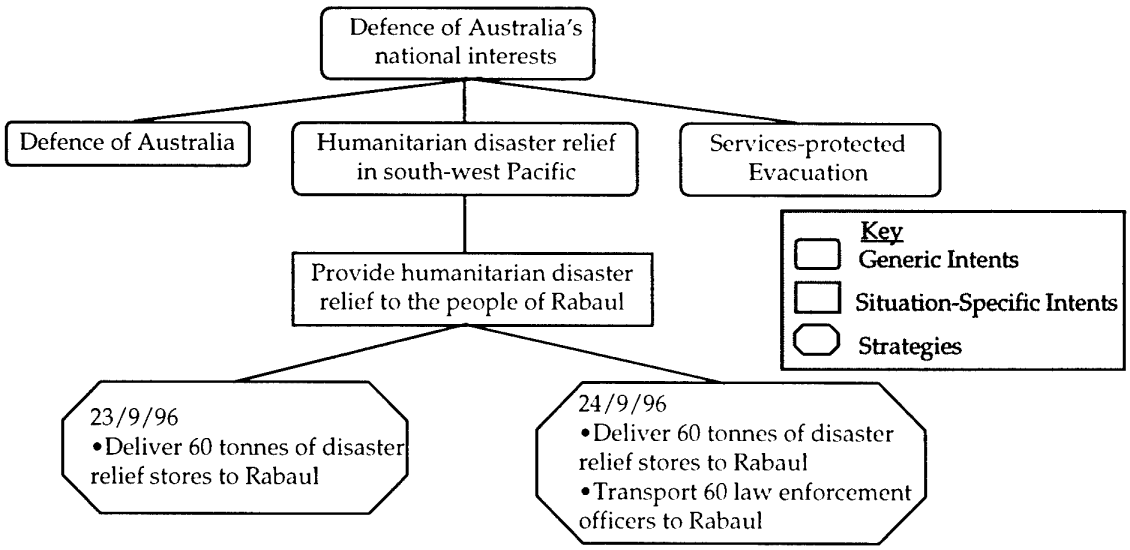

Figure 1.2. Generic intents, situation-specific intents, and strategies

Framing is the process people in organisations perform to conceive situations from an organisational perspective. It is a form of inquiry for action (Dewey 1938; Schön1993) that enables people to assign meaning to their real-world experience (Watzlawick, Weakland, and Fisch 1974) and create a perspective for viewing the real-world environment. The framing process describes how people in organisations use intents to recognise real-world events that are relevant to an organisation, conceive situations, and construct new intents that may change the ethos of an organisation. Descriptions of intents are used as generative metaphors for constructing the initial framing knowledge representations for framing the situation. The framing activity may involve redescribing concepts in the framing knowledge representation, constructing new intents that are used to coordinate activities across activity systems and institutions, and sometimes constructing new intents that change the ethos of the organisation.

1.3 Aim of this thesis

This thesis aims to show how computer systems can aid people framing situations that change an organisation's behaviour.

The body of this thesis is divided into seven chapters:

- Chapter 2 identifies background knowledge from research into the sociology of knowledge, organisational theory, artificial intelligence, computer science, and social theories of learning that provides the basis for the later chapters.
- Chapter 3 defines a language for describing organisations and proposes a new theory of framing. A case study based on the Australian Defence Force's participation in providing humanitarian disaster relief aid to the people of Rabaul after volcanic eruptions is used to illustrate this theory.
- Chapter 4 presents a new knowledge representation technique called descriptive networks and describes the sixteen framing elements. The descriptive networks knowledge representation has been developed to cope with the ephemeral nature of concept descriptions. Descriptive networks provide a rich environment for people to frame situations by enabling a concept to have many descriptions. The real utility

of descriptive networks is in the ability to support the evolution of descriptions of concepts as events in the real-world unfold.

Sixteen framing elements are defined to support the theory of framing and the construction of framing knowledge representations. These framing elements cover unstructured information, structured information, situational contextual information, and organisational contextual information.

- Chapter 5 describes an implementation of the descriptive networks knowledge representation and the sixteen framing elements in a system called FRAMER. FRAMER was developed to demonstrate how the theory of framing, the descriptive networks, and the sixteen framing elements can be used to aid people framing situations that change an organisation's behaviour.
- Chapter 6 documents a second case study that demonstrates the utility of the theory of framing, the descriptive networks, the sixteen framing elements, and FRAMER for aiding people framing situations that change an organisation's behaviour. The case study is based on work performed in the Defence Science and Technology Organisation (DSTO) defining the role of the DSTO C3 Research Centre in a new program of work called Takari.
- Chapter 7 draws conclusions about the utility of the theory of framing in developing computer support for aiding people framing situations that change an organisation's behaviour.

2. Background

One day a boy said to Richard, "See that bird? What kind of bird is that?"

I said, I haven't the slightest idea what kind of bird that is."

He says, "It's a brown-throated thrush. Your father doesn't teach you anything!"

But it was the opposite. He had already taught me: "See that bird?" he says. "It's a Spencer's warbler." (I knew he didn't know the real name) "Well, in Italian it's a Chutto Lapittida. In Portuguese, it's a Bom da Peida. In Chinese, it's a Chung-long-tah, and in Japanese, it's a Katano Tekeda. You can know the name of the bird in all the languages of the world, but when you're finished, you'll know absolutely nothing whatever about the bird. So let's look at the bird and see what it's doing - that's what counts --Richard Feynman quoted in *Genius*, James Gleick, p28

There is a general movement in the social sciences away from rational analyses of human behaviour toward understanding the role of the real-world environment in human affairs. This chapter starts by describing a sociological view of knowledge that argues that the real-world environment is socially constructed. This sociological perspective is used to construct a framework that argues that the real-world environment is characterised as a set of messy, interacting wicked problems, and that social worlds are the appropriate unit for analysing wicked problems. The implications for viewing organisations as open, learning systems is then explored. This framework of wicked problems and social worlds are used as the basis for describing research in artificial intelligence, and computer supported collaborative work. This chapter concludes by identifying the key concepts that will be used by the author to construct a theory of framing in an organisational context.

2.1 A Sociological View of Knowledge

The sociology of knowledge is concerned with the relationship between human thought and the social context within which it arises. It argues that the real-world environment in which people act and inquire is socially constructed. This section identifies the key concepts from the sociology of knowledge that are relevant to framing in an organisational context and is largely based on Berger and Luckman's (1969) work.

Knowledge in society is structured in terms of what is generally relevant, and what is relevant only for specific roles. Roles are mediators of specific sets of knowledge. Assuming a role entails that an individual has a different perspective on the real-world environment compared to other people performing different roles. This different perspective results from the individual assuming a role and being inducted into specific sets of knowledge, performing actions based on this knowledge, and interacting with other actors according to specific patterns of interaction. An individual can change this set of knowledge for a role as a result of participating in activities. Assuming a role enables an individual to participate in the social world.

Institutionalisation of behaviour occurs whenever a pattern of social interaction occurs on a regular basis, for example, the bargaining process between a buyer and seller. Institutionalising patterns of interaction is dependent upon developing appropriate role typologies. These role typologies create the knowledge that actions of type X will be performed by roles of type X, and predefines patterns of conduct. The implication of developing role typologies is that certain actions will only be performed by a particular role, and that role-specific knowledge will be socially distributed.

The generally relevant set of knowledge in a society includes a typology of how expert knowledge is distributed across the society, and the common objective problems for the society. For example, if the telephone doesn't work an individual may not know how to repair it. But the individual will know who to call for assistance. In this case, the broken telephone is the common objective problem, the knowledge for how to fix the telephone is the role-specific knowledge, and the knowledge of who to call is the generally relevant knowledge.

Language plays a dual role in socially constructing the real-world environment. Through language a community constructs meaning by objectifying significant events and typifying experience under broad categories. Language is also the means of accumulating knowledge that is built from people's real-world experiences. This knowledge is continually being accumulated and is transmitted between people through spatial, temporal and social dimensions. Through language, every individual in a community has access to, and co-constructs, this knowledge.

To overcome the segmentation caused by the social distribution of knowledge within an institution, *integrative meanings* are used to provide a common objective problem that encompasses the activities performed by all the roles. These integrative meanings are not goals, they cannot be solved. Instead, they provide a meaningful relationship between the activities performed by different roles and form the basis for enabling coordination across an institution in an ongoing manner. Understanding an institution requires an understanding of both the historical processes in which it was produced, the future situations in which the institution expects to be involved, and the manner in which the institution manifests its integrative meanings.

2.2 The Nature of the Real-World Environment

Our understanding of the real-world environment is socially constructed (Berger and Luckman 1969) and has both a physical- and cultural-basis (Dewey 1938). The real-world environment is an interacting, open system (Rittel and Webber 1973). People perceive this environment as being equivocal, uncertain and inconsistent (Daft and Lengel 1986). People's activity is situated. It interacts with, and changes, this environment.

People frame situations and extract problems as a method of coping with the real-world environment. These problems can be viewed as either well-structured problems or wicked problems. Viewing the real-world environment in terms of well-structured problems requires people to select a problem space and map things from the environment to the problem space for rational problem-solving. However, no problem exists in complete isolation. Real-world problems are messy and consist of a series of inter-related problems (Ackoff 1974). Resolving one problem at a point in time triggers

side-effects that cause symptoms in other problems. Rittel and Webber (1973) named these types of problems *wicked problems*.

Wicked problems have the following characteristics (Rittel and Webber 1973):

- there is no definitive formulation of a wicked problem. Different viewpoints frame reality in different ways, none of which are completely correct nor incorrect. For example, in the 1950's urban housing problems were framed as "blight and renewal", in the 1960's these problems were framed as "natural community and its dislocation" (Schön 1993).
- wicked problems are ongoing. There are no final goal states and they cannot be completely solved. Instead they can only be resolved at a point in time, to reappear again and again.
- solutions to wicked problems can only be evaluated in terms of better or worse. There is no objective way of evaluating these solutions. Since there is no definitive formulation of a wicked problem, and wicked problems are ongoing, there is no objective way of evaluating a solution to the wicked problem. Instead, there is only objective evaluation of possible resolutions in terms of the current formulation of the wicked problem at a point in time, recognising that the wicked problem will reappear at a later date. For example, viewing urban housing as "blight and renewal" meant that any resolutions were evaluated in terms of removing the "blight" (Schön 1993), but these resolutions did not solve the urban housing problem.
- viewing the real-world environment as an open, dynamic system means that there is no opportunity to learn how to formulate a wicked problem by trial and error. Every trial counts because as events in the real-world environment unfold, the manifestation of the problem evolves. Once the wicked problem is formulated, the opportunity exists to learn by trial and error how to resolve the problem.
- it is not possible to enumerate all the solutions to a wicked problem because the solutions depend upon the framing of the problem. Changing the framing changes the set of possible solutions.

- every wicked problem is unique. There is always an additionally distinguishing feature that negates the similarities with other situations.
- every wicked problem is a symptom of another problem due to the messy nature of real-world problems.

2.2.1 Wicked Problems versus Ill-Structured Problems

Newell's (1969) research into reasoning about problems divided the world into well-structured and ill-structured problems. Well-structured problems can be formalised, whereas ill-structured problems cannot be formalised and require people to solve them. Simon (1973) showed that well-structured problem-solving techniques could be applied to ill-structured problems. He then redefined the relationship by stating that any problem with a large base of potentially relevant information may appear to be an ill-structured problem.

Simon's conceptualisation of ill-structured problems misses the inherent difficulties in reasoning about wicked problems (Rittel and Webber 1973). The first difficulty is defining the valuative framework that enables the relevant set of information to be defined. The second difficulty is recognising that wicked problems can't be solved, they can only be resolved at a point in time. The third assumption is the inability to cope with discontinuous change which invalidates the utility of the historical problem space. Newell's notion of requiring people to solve ill-structured problems implicitly recognises these difficulties and the role of framing in reasoning. For this reason, wicked problems are more than ill-structured problems.

2.2.2 Wicked Problems versus Novel Problems

Simon (1971) stated that problems exist on a continuum ranging from routine problems through to totally novel problems. Routine problems are well-structured. Novel problems are unstructured with no method for handling the problem. Simon proposed using general problem-solving techniques and heuristics for dealing with novel problems.

Simon's description of novel problems assumes that these problem have been defined, and a valuative framework has been put in place for determining relevant information.

All that remains is to find some method to solve the problem. Simon misses the framing process that defines the novel problem. For this reason, wicked problems are more than novel problems.

2.3 Units for Analysing Organisations

This section evaluates a range of analytical units for describing the work conducted in organisations. The focus of this section is describing organisations from a social perspective. Two complementary social theories are described: social worlds/arena theory (Strauss 1978) and communities of practice (Wenger in press). Social worlds are a top-down approach that focuses on how people organise themselves. In contrast, communities of practice are a bottom-up approach that focuses on how membership of a community of practice involves the issues of engagement, learning and identity. Social worlds are selected as the appropriate analytical unit for describing how the Australian Defence Force (ADF) conceives situations from an organisational perspective. Finally, the social worlds approach is contrasted with task-based, distributed cognition, and activity theory approaches.

2.3.1 Social Worlds / Arena Theory

The social worlds / arena theory approach focuses on how people organise themselves including both formal and informal social groupings (Maines 1991; Strauss 1978; Strauss 1984). The strength of this approach is in analysing both the structures and social processes of situations where overlapping and conflicting social worlds come together around shared tasks (Clarke 1991). The key concepts in this approach are: social worlds, arenas, locales, bridging agents and boundary objects.

A *social world* is a group with shared commitments to at least one primary activity, and shares resources to meet their goals. Members of a social world share a similar perspective on the real-world environment and develop a universe of discourse. Examples of social worlds include opera, football, stamp collecting, homosexuality, and medicine. Social worlds vary considerably in their size, primary activity, organisational complexity, technology, geographical distribution and lifespan (Strauss 1984). The focus on commitment to a primary activity sets a boundary for a social

world. However, this boundary may be relatively porous and messy, enabling people to move between social worlds (Clarke 1991).

The social world/arena theory approach seeks to understand patterns of action and change (Clarke 1991). This approach recognises that the real-world environment is continually changing and that social worlds are continually being formed, splintered, and destroyed. Two key notions in this approach are the processes of segmentation and intersection. *Segmentation* is the process of forming sub-worlds. Forming sub-worlds means that new activities, resources, and universes of discourse are created. For example, in Australia a new sub-world called "super league" has been formed from the "rugby league" social world.

A single social world cannot be studied in isolation. The relationship between social worlds is defined by how they *intersect*. Intersecting processes include cooperating, competing, borrowing, migrating from and into, invading, defending, and allying (Strauss 1984).

Social worlds intersect either formally in arenas, or informally in locales. *Arenas* are enduring frameworks that are designed to enable people from multiple social worlds to perform an activity. An arena is a metaphorical site of action where issues are debated and negotiated between social worlds. The different social worlds represented in the arena provide different perspectives and resources for acting. An arena is designed to provide a site, which may be virtual, for people to act collectively, and provides resources and technology to perform an activity. For example, supermarkets are arenas that are designed to enable the buying and selling of groceries (Lave 1988). A supermarket has many grocery items on display, grouped together into categories, shopping trolleys are provided to enable shoppers to collect grocery items, a cash register area enables shoppers to pay for all their grocery items at one time, and the number of shopping trolleys, grocery items on display, and registers reflects the volume of shoppers and purchasing transactions for which the supermarket was designed.

Locales enable social worlds to intersect informally (Lofland 1991). These informal interactions may be about any topic, they are not constrained to a particular activity. Locales may or may not be designed. For example, coffee shops, pubs, and officer's

messes are designed to enable social interaction, whereas corridors and water fountains are normally designed for other purposes. Over time, patterns of interaction may develop in a locale where members of social worlds informally discuss their activities. These interactions may develop to the extent that artifacts are used to facilitate the discussion over a period of time, such as whiteboards and noticeboards. If these interactions are formally recognised as being useful, an arena may be designed to facilitate these interactions.

Bridging agents are people who bridge the social gap between intersecting social worlds (Suczek and Fagerhaugh 1991). The nature of the work conducted by bridging agents requires them to maintain a neutral position so they can simultaneously represent the interests of multiple social worlds. Examples of bridging agents include mediators, facilitators, translators and diplomatic envoys.

Boundary objects are things that exist at the intersection of multiple social worlds and enable the social worlds to coordinate and align their activities for some purpose (Star 1989). Examples of boundary objects include artifacts, documents, structured messages, situation awareness displays, and maps. The boundary object is translated to meet the needs of each social world. Designing a boundary object requires negotiation between social worlds to meet both the demands of each social world, and the requirements for coordinating and performing the activity in the arena.

2.3.2 Communities of Practice

Wenger (in press) proposes communities of practice as the appropriate unit of analysis in a social theory of learning. Communities of practice can be considered as a specialised type of social world. Participants in a community of practice develop *joint enterprises*, which are similar to the social world notion of shared commitments to a primary activity. Participants in a community of practice also develop *shared repertoires* which are similar to the social world notion of sharing resources.

The distinction between communities of practice and social worlds is that communities of practice focus on what people do, how people give meaning to their actions through engagement, how people form identities through their participation and how membership of a community of practice is a matter of engagement and learning. A

community of practice is defined in terms of a sustained history of mutual engagement, negotiated joint enterprise, negotiated meanings, development of a shared repertoire, and the introduction of newcomers to the community of practice.

Practice is how people organise themselves to perform a particular type of work. It comprises both the explicit and tacit processes performed by people. Wenger defines practice as a duality between participation and reification. Practice can be reified in the form of artifacts such as standard operating procedures, directives, tools and language. These reifications require people's participation to interpret, use and make sense of these reifications in a particular situation. For example, F18 pilots reify their practice in the form of tactics and a vocabulary for describing the practice of conducting F18 operations. An F18 pilot's participation occurs by actually flying the aircraft and interpreting the tactics in the current situation.

Identity is how people conceive their place in the world. People create an identity by becoming members of a community of practice. For example, an F18 pilot will strongly identify with being an F18 pilot, and will tell you so! Membership of a community of practice is not simply a matter of joining a group. Instead, people serve an apprenticeship to learn the practice and become full members of a community of practice. For example, a new pilot joining an F18 squadron must learn how to fly the aircraft, the tactics of flying in pairs, and the tactics of flying larger formations consisting of multiple pairs performing different types of missions. The new pilot will learn about the history of the squadron, how to behave like an F18 pilot, and what it means to be an F18 pilot.

Learning can be defined at two levels. Firstly, an individual learns to become a member of a community of practice by serving an apprenticeship. Secondly, as a member engaged in the practice of the community of practice, an individual can conceive new ways of conducting the practice. For example, F18 pilots are continually refining their tactics as they conduct exercises and operations.

Negotiating meaning is the social process of using language to construct and reason about the practice people are engaged in doing. Joint enterprises are socially negotiated and form the basis for action. Joint enterprises are not just goals, they involve establishing relations of mutual accountability between participants that

becomes part of the practice. Due to the social distribution of knowledge, and different participants performing different roles, each participant may not have the same understanding of a joint enterprise. The joint enterprise is used to interconnect people's responses to a situation. Different understandings of the joint enterprise only need to be addressed and resolved when they directly interfere with mutual engagement and achievement of the joint enterprise.

Interconnecting communities of practice in an organisation can be achieved by using boundary objects to pass information between communities of practice, or by using people who are members of multiple communities of practice to perform a brokering role as shown in Figure 2.1.

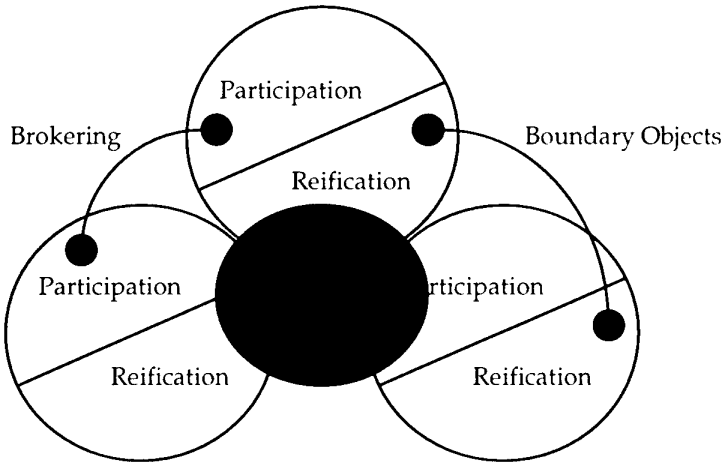

Figure 2.1 Connections across communities of practice (Wenger in press)

Brokering is the process in which an individual introduces elements of one community of practice into another. The process of brokering requires the individual to reinterpret the meaning of an element from one community of practice in terms of another community of practice and then introduce this element to the other participants of the community to enable them to negotiate its meaning and utility. The process of brokering results in the possibilities for new meanings in a community of practice. The distinction between brokering and bridging is that brokering is a proactive process that not only translates, but reinterprets meanings across communities of practice.

2.3.3 Selecting an Analytical Unit for the ADF

This section argues that social worlds are an appropriate analytical unit for describing the organisational context in which the framing activity occurs. The ADF is represented as a social world and segmented into different types of social worlds. An analysis is then conducted into whether any of these social worlds are communities of practice.

The ADF can be represented as a social world. It is currently vertically segmented into four social worlds: a joint organisation and three single services comprising the army, navy, and air force. The ADF can also be horizontally segmented into three levels of decision-making: strategic, operational, and tactical. A number of social worlds and arenas exist at each of these levels to facilitate decision-making. The arenas are designed to facilitate decision-making by enabling multiple social worlds to intersect.

The strategic level is responsible for conceiving the situation from an organisational perspective and defining the goal for the situation. Conceiving the situation involves negotiating across social worlds both internal and external to the ADF. Social worlds negotiate within the ADF to define the military objectives. The ADF negotiates externally with social worlds from foreign military organisations and other government departments to align the military objectives with the diplomatic, political, and economic objectives of the nation. The operational level is responsible for defining how an operation will be performed, what forces, strategies, and organisation structures will be required. The tactical level is responsible for devising tactics and performing the operation. Feedback loops from the tactical to the operational and strategic levels enable informed decision-making at all levels.

The joint organisation is responsible for conducting any operation the ADF is engaged in. At the strategic level, the situation is conceived in the Headquarters Australian Defence Force (HQADF) arena. At the operational level, a joint force structure is created in the Headquarters Australian Theatre (HQAST) arena. A joint force structure is created from the tactical units in the single services and is customised to the needs of the situation.

The three single services are responsible for raising, training and maintaining a capability. Each of the single service social worlds can be further segmented. For example, the air force social world can be segmented into pilots, navigators, logisticians, engineers and air traffic controllers. The pilots social world can be segmented into F18 pilots, F111 pilots, and transport pilots. The F18 pilots social world can be further segmented into F18 pilots at 3 Squadron, 75 Squadron, and 77 Squadron. Members of these social worlds are also members of social worlds that span organisations. For example, members of the ADF's F18 pilots social world are also members of the larger F18 pilots social worlds that includes pilots in the United States Navy and Canadian Air Force.

The specialised social worlds at the tactical level, such as the F18 pilots at 3 Squadron, exhibit the characteristics of a community of practice. An individual joining the ADF is trained in a specialisation. The person is trained in how to perform their work, and how to interact with people both within and external to their social world. As part of this training, the person learns a set of values, learns the history of the community of practice, learns the language, and learns how to act as a member of the community of practice. By participating in the activities of the community of practice, the individual can participate in changing the community of practice by negotiating the joint enterprise and shared repertoire. For example, an F18 pilot may find variations on existing air combat tactics that defeat the existing tactics. As a result of being a member of the community of practice, the individual's identity is firmly enmeshed with their participation in a community of practice. For example, an F18 pilot will not just state that they are a pilot, but that they are an F18 pilot in 3 Squadron.

The strategic level HQADF social world does not exhibit the characteristics of a community of practice for a number of reasons including: problems defining the social world, joint organisation cultural problems, regular turnover of staff, lack of shared history, and lack of identity. Membership of the HQADF social world is dependent upon the situations in which the ADF is currently involved. The HQADF social world may include people from foreign military organisations and other government departments, in addition to the core military staff. The non-ADF personnel act as brokers for short periods of time, often for several days or a couple of weeks. The

regular turnover of military staff every two to three years means that membership of the social world is fairly fluid.

The fluidity of membership is exaceberated by the joint organisation cultural problems in the ADF. In the 1970's, the ADF formalised the concept of joint operations and the need for a joint organisation structure. However, an individual's career progression is still based on single service structures. An individual will be posted from their specialised social world to HQADF for a two to three year period, and then return to their specialised social world. This means that there is no continuity of membership within the joint organisation, and no career progression within the joint organisation.

The lack of continuity of membership in the joint organisation has meant that an individual's identity is expressed in terms of their specialised single service social world. There is no concept of a joint identity from an individual's perspective. The lack of joint identity and the lack of continuity of membership is manifested as a lack of shared history. Unlike the specialised social worlds at the tactical level, there is no concept of "unit history" where people can view the activities of the social world over time, and the membership of these social worlds who participated in these activities.

For these reasons, social worlds are the appropriate analytical unit for describing the strategic level of decision-making, and the HQADF arena in particular. Since this thesis focuses on how situations are conceived from an organisational perspective, and the strategic level is responsible for conceiving situations for the ADF, social worlds will be the analytical unit used for the remainder of this thesis. Interesting research questions that arise as a result of this analysis include whether there is any value in changing the culture of the joint organisation in the ADF to behave like a community of practice; and whether in other organisations the strategic-level social worlds also do not exhibit the characteristics of communities of practice.

2.3.4 Tasks

The aim of a task analysis is to capture a set of generic tasks required to perform a particular type of work that can be applied to different situations. A task analysis involves pre-defining the way work is performed. The task analysis may be conducted by structured interview, scenario analysis or use case analysis (Jacobson 1992), or by

observing work being performed. Each identified task is described in terms of the sequence of operations required to perform the task, and all the information required to perform each operation. These operations and information are then represented in a problem space that describes how the tasks are organised to achieve goals and are used for rational, well-structured problem-solving.

The nature of a task analysis assumes a common language exists for reasoning about situations in performing a particular type of work. The process of negotiating meaning in a community of practice is about defining a common language by describing tacit knowledge, reinterpreting reifications and improvising to meet the requirements of the real-world environment. A task analysis is actually based on analysing the results of performing the negotiating meaning process for one or more situations.

2.3.5 Distributed Cognition

Distributed cognition theories (Hutchins 1993; Hutchins 1995) focus on understanding the holistic nature of a cognitive system. A cognitive system is a distributed collection of interacting people and artifacts working together to achieve a goal. A distributed cognition approach reveals how analysing the tasks performed by individuals is an inadequate description of a cognitive system because it misses how artifacts are used to coordinate the work of individuals, and how these coordinations can be restructured to adapt to changes in the real-world environment.

Hutchins (1993) documents how the career progression of individuals performing the navigation task on United States Navy ships follows the information flow through the navigation positions, albeit on a much slower timescale. Section 2.3.3 documents how a similar progression occurs in the specialised social worlds at the tactical level of the ADF. However, not all social worlds exhibit this progression, for example, the joint organisation in the ADF. Distributed cognition theories do not investigate how and why the social world and arena was designed to enable the cognitive system to work, and how improvisation may occur not only within a social world, but as a result of interacting with members of other social worlds.

2.3.6 Activity Theory

Activity Theory (Leontev 1978; Nardi 1996; Vygotsky 1978) attempts to overcome the limitations of tasks by exploring the relationship between the work individuals do and the real-world environment. This relationship is called an activity and includes the social and historical context in which the work is performed. Artifacts are the means of mediating human experience in these activities.

Leontev (1978) described the relationship between activities and problem spaces as shown in Figure 2.2. Each activity has a motive. The aim of acting in an activity is to transform the motive into an outcome through the mediation of tools and artifacts. An activity consists of a set of actions that, taken together, produces the desired outcome. Each action is associated with a goal. Thus the motive manifests itself as a set of goals in actions. Activities are dynamic structures that change as the real-world changes. The motives, goals and artifacts comprising the activity can be constructed and adapted over time.

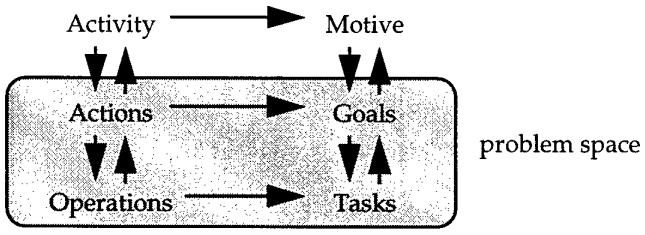

Figure 2.2 Activities versus problem spaces, adapted from Leontev (1978)

Recent research into Activity Theory has focused on making explicit the social aspects of work as shown in Figure 2.3 (Engestrom 1993). The aim of acting in an activity is still to transform the motive into an outcome through the mediation of tools. The concept of community makes two relationships explicit. The relationship between an individual and community is mediated by rules that define norms, conventions and social relations. The relationship between the motive and community is mediated by a division of labour that specifies how the motive is transformed into the outcome.

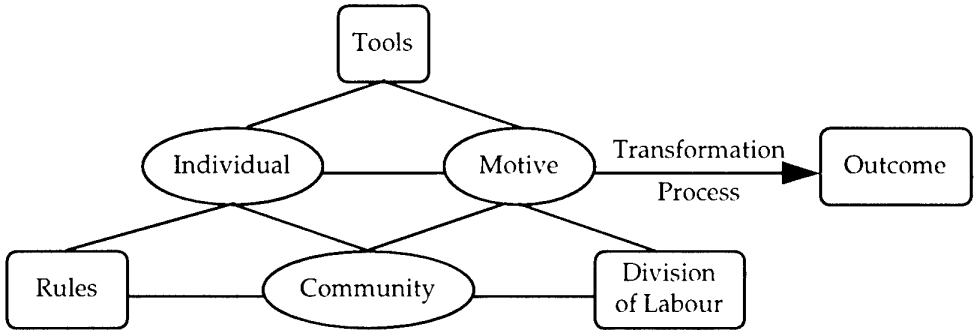

Figure 2.3 Incorporating the social aspects in Activity Theory (Engestrom 1993)

Activities provide a richer unit of analysis for reasoning about the messy nature of the real-world environment. Not only can each individual be involved in many activities, but an individual action can be performed to simultaneously satisfy different goals in different activities.

The efforts to include the social aspects in Activity Theory assume that there is a common language for reasoning about activities. There is currently no support for defining a common language through the process of socially negotiating meaning, defining connections between communities in the form of boundary objects and brokering, or defining integrative meanings that interconnect the different types of work across an organisation. Current descriptions of Activity Theory provide no basis for analysing the intersections between communities, the arenas in which these intersections occur, how new communities may be formed, or the coordinated, improvisatory behaviour across communities.

2.4 Organisational Theory

Research into organisational theory has increasingly recognised the relationship between organisations and the environment. This research has evolved from rational, natural system theories that viewed the organisation as a closed world, to open, learning system theories that recognise that organisations are dependent upon their environment for their survival (Scott 1967). This section describes some of the features of the rational, natural system approaches and identifies the emerging features of the open, learning system approaches.

Rational, natural system theories viewed the organisation as a closed world, with the aim of creating structure and certainty despite the environment. These theories view organisations as having well-defined strategies that define the objectives, or ends, of an organisation over a long period of time. These strategies are used to identify the capabilities, or means, required to achieve these objectives. The organisation acquires these capabilities, defines standard operating procedures for using these capabilities, creates roles by the division of labour, allocates tasks to roles, creates an organisational structure and formal management processes to ensure efficient performance by the organisation in using the capabilities to achieve the objectives. These strategies are specified and implemented in a top-down fashion and are often reviewed on a yearly basis.

Several problems were identified with the strategic planning approach. The principle of bounded rationality (March and Simon 1958; Simon 1947) states that people often do not make optimal decisions due to limits on the information available to them, and limits on their ability to cognitively process the information. Instead, they make decisions relative to some frame of reference by searching for alternatives and selecting satisfactory alternative. The formal task-based approach for performing work in an organisation misses the value of the informal activity by which people make the task-based approach function (Galbraith 1979; Mintzberg, Raisinghani, and Theoret 1976). Organisations adopting the formal, task-based approach find it difficult to cope with discontinuous change in the real-world environment and remain competitive. Finally, it is difficult to map between the soft mission, purposes and objectives of an organisation to the hard goals that people in an organisation perform in a task-based approach.

Warfield (1973) proposed the notion of intents to encompass both the soft and hard aspects. *Intents* are organised hierarchically into intent structures. The higher-levels of the intent structure contain the missions, purposes, objectives and shared visions of an organisation. The lower-levels reveal how the higher-levels are manifested as goals, and are linked to the strategies for achieving these goals. The root-node represents the integrative meaning that defines the main purpose of the organisation, or the reason the organisation exists. Viewing intents in this manner enables an organisation to

move out of the closed-world problem of managing resources into the problem of leveraging resources to find new ways of doing business to reach seemingly unattainable goals (Hamel and Prahalad 1989).

Open, learning system theories recognise that adaptation of fit is an ongoing process in a continually changing environment (Senge 1992). Senge (1990) identifies two types of organisational learning: adaptive learning and generative learning. Adaptive learning is reactive, it is about coping with environmental change. Generative learning is proactive, it is about creating the environment the organisation wants to work in.

Organisational learning, or adaptation of fit, occurs by enabling people to develop new ideas about the real-world environment in social worlds. These social worlds may be part of the existing organisational structure, they may be project teams that cut across the organisational structure, or they may be informal groupings in the workplace. People develop new ideas by surfacing and testing mental models, then conceive shared visions, or joint enterprises, that provide an aiming point for the community of practice to work towards (Argyris and Schön 1978; Senge 1992).

There are several interesting features in this approach to organisational learning. Firstly, new strategies can emerge from all levels of the organisation (Burgelman 1988; Mintzberg and Quinn 1988). Secondly, the shared vision may identify a new way of using an existing capability, the need to acquire a new capability, or it may identify a new objective for the organisation.

Communicating these new shared visions to other people often occurs in the form of scenarios. Scenarios are models predicting how the future may unfold given certain types of changes to the environment, and how the organisation needs to change its strategies to take advantage of these new environments (Dewar et al. 1993; Geus 1988; Wack 1985a; Wack 1985b). Scenarios are a method of situating shared visions. In an organisational learning approach, scenarios are used to negotiate meaning, unlike task-based approaches where scenarios are used to identify the tasks required.

Implementing these new shared visions changes the organisation's fit. These new shared visions often change the capabilities of an organisation, the role structure and knowledge requirements of each role, the management processes and the organisation

structure. More importantly, the multi-disciplinary nature of developing new shared visions results in the establishment of new patterns of informal social interactions (Galbraith 1979) across the organisation, leading to more effective and efficient work practices.

2.5 Artificial Intelligence

This section focuses on the knowledge-based systems approach to artificial intelligence. Knowledge-based systems are viewed as containers of knowledge used to solve problems. The knowledge-based systems approach is compared with the theory of framing presented in this thesis. It starts by presenting an overview of artificial intelligence techniques and critiquing these techniques from a social worlds perspective. An example based on Lenat's (1975) Beings research is used to highlight these differences. Finally, distinctions are made between the artificial intelligence approach to metaphorical reasoning and Schön's (1993) research into generative metaphors.

2.5.1 Overview of Artificial Intelligence

Research in artificial intelligence has focused on carefully crafting containers of knowledge to solve a particular type of problem. Crafting containers of knowledge requires people to design an appropriate knowledge representation, design and implement an appropriate knowledge acquisition strategy, and select an appropriate inference strategy.

Solving problems using artificial intelligence systems follows a task-based approach. The goals, tasks and information required to solve a problem is represented in a container of knowledge either explicitly using symbols in knowledge-based systems, or implicitly in the form of neural networks (Rumelhart and McClelland 1989). Containers of knowledge using a symbolic representation can be viewed as state spaces, task spaces, problem spaces (Newell and Simon 1972), qualitative models (Clancey 1989), or agents (Newell 1982).

An artificial intelligence system may be organised as a single container of knowledge, or multiple containers in the form of multiple knowledge sources for a blackboard

(Engelmore and Morgan 1988), or a distributed agent system (Bond and Gasser 1988). A multiple knowledge container system requires people to design appropriate coordination mechanisms between knowledge containers. These coordination mechanisms assume a common language is used for reasoning and that the aim of coordination is simply to pass pre-defined types of information between knowledge containers. There is no concept of conceiving new types of situations in existing artificial intelligence systems.

Once the goal has been achieved in an artificial intelligence system, no more reasoning is required. However, an organisation's integrative meanings are ongoing in nature, are situated as wicked problems and manifest themselves as goals to be resolved at a point in time. Reasoning about these goals cannot be done in isolation, instead reasoning occurs in a socio-historical context where meanings are situated and renegotiated.

Methods for representing knowledge in these containers include semantic networks (Quillian 1968), state spaces (Newell and Simon 1972), rules, frames (Minsky 1975) and scripts (Schank and Abelson 1977) which are used for default reasoning, and cases (Kolodner 1993). All these knowledge representation techniques take a well-structured problem-solving approach and assume that there is a single correct description, and a single correct meaning, for a concept, and that these descriptions are adequate for reasoning about the real-world environment without further negotiation of meaning. The problem with this approach is that additional attributes need to be added to the description of a concept to handle each possible variation of a situation (Brachman 1985). These descriptions rapidly become large, unwieldy, and computationally expensive. This approach is inadequate for reasoning about wicked problems which requires negotiating meaning.

Research into the development of non-monotonic logics (Krause and Clark 1993) to support contextual reasoning (Guha 1991; McCarthy 1993) aims to overcome the problems identified by Brachman by enabling concepts to have different descriptions in different contexts. For example, the simple concept "in" has over two dozen context-dependent meanings (Lenat 1995). These logics still only allow one meaning for a concept to exist in each context, with carefully defined lifting rules that automatically

map between these different descriptions as the automated reasoning system changes contexts. There is no support for negotiating meaning in these logics. These logics only implement a post-hoc rationalisation of how people have mapped concepts between contexts.

The knowledge in these containers can be acquired by manual entry from human experts before the system is used, by being trained (Rumelhart and McClelland 1989), by learning new cases (Kolodner 1993), by humans adapting the knowledge base for new problems (Compton et al. 1993), by the system learning from its reasoning and chunking this knowledge (Laird, Newell, and Rosenbloom 1987). Knowledge acquisition is still a major bottleneck for building knowledge-based systems (Hayes-Roth, Waterman, and Lenat 1983), and acquiring standardised knowledge across multiple human experts is still an open research topic (Davis 1982).

The brittleness of knowledge-based systems and the knowledge acquisition bottleneck led to the development of CYC. CYC aims to be a knowledge-base of common-sense knowledge that is used by artificial intelligence programs when they exhaust their domain-specific knowledge (Lenat and Guha 1989). The CYC project has spawned research into developing languages for constructing ontologies (Gruber 1992), accessing knowledge from these ontologies (Finin et al. 1994), and communicating knowledge between ontologies (Genesereth and Fikes 1992). Knowledge in CYC is organised into context-specific, self contained micro-theories (Guha and Lenat 1990). Complex concepts in these micro-theories are constructed from simpler concepts to overcome *the representation trap* (Lenat and Guha 1989). *The representation trap* occurs when knowledge is represented as complex predicates such as "LaysEggsInWater" for a specific problem. An artificial intelligence system using this predicate would be unable to answer queries like "LaysEggs". *The representation trap* occurs because (Lenat and Guha 1989, p16):

> "... human beings are so good at abstracting to just the right level of abstraction that we aren't conscious of the mental 'work' we're doing"

The knowledge-based systems approach has assumed that these abstractions can be reduced to a set of descriptions, and a set of operators for manipulating these

descriptions. In the real-world, people's descriptions of concepts evolve as their understanding of the world changes as a result of acting in the world (Clancey in press). The way people conceptualise the world may be non-verbal in nature (Bamberger and Schön 1983; Clancey in press), or they may not be able to articulate their concepts until they are acting in a situation (Argyris and Schön 1978; Polanyi 1962). The implication is that any knowledge-based system relying upon the articulated post-hoc descriptions for how people solved a problem will always contain an incomplete set of knowledge.

The problem with acquiring knowledge for artificial intelligence systems is that it must be defined before its used. CYC makes this more difficult by stating that knowledge must be defined in a generic way that enables it to be used to answer unanticipated questions. In contrast, communities of practice negotiate meaning to define a situated language of basic-level concepts (Rosch et al. 1976), rather than simply extending an existing vocabulary. The process of negotiating meaning is not just about mapping knowledge between ontologies, but also about brokering concepts from one social world and reinterpreting them in another social world to find new ways of describing and acting in the real-world environment.

Inference strategies for solving problems can be viewed in terms of searching the container of knowledge for a solution, being guided by heuristics (Newell and Simon 1972), heuristic classification (Clancey 1985), applying model-manipulation operators (Clancey 1989), using generic tasks (Chandrasekaran 1986), or employing inductive, deductive, or abductive reasoning techniques. Knowledge-based systems using these techniques only solve problems with narrow, well-defined domains and are notoriously brittle for any problem outside this domain. The reason for this brittleness is the inability to negotiate new meanings for achieving existing goals coupled with the inability to define new types of goals.

2.5.2 Lenat's Beings

Lenat (1975) explored the implications of organising knowledge as a set of interacting modules by building a system called PUP6. PUP6 modelled a meeting of human experts who each contributed specialist knowledge to a common task. Each expert was

modelled as a *Being* and contained the knowledge required to perform a particular task. These *Beings* were used in PUP6 for the task of automated programming.

This approach assumes that there is a common problem, a common language, a common set of concepts for reasoning about the problem, and that the knowledge exists to solve the problem. This common problem, set of concepts for reasoning about the problem and a coordination strategy was carefully crafted into the *Beings* knowledge representation. This knowledge representation was then used to solve particular instances of the automated programming problem by using the pre-specified coordination strategy to enable the *Beings* to exchange data to construct the appropriate code. The key to understanding why PUP6, and artificial intelligence systems in general, work is that the knowledge representation is carefully crafted to ensure the system will solve problems (Lenat and Brown 1984).

In contrast, social worlds reasoning about wicked problems cannot assume a common problem, a common language, a common set of concepts, that the knowledge exists, or that any conventions exist for social interaction. Instead this commonality is constructed through the social process of brokering concepts across social worlds, negotiating meaning and constructing intents in the situation. The outcome of negotiating meaning is a knowledge representation that will solve the problem. However, due to the changing nature of the real-world environment and the need to continually negotiate meaning, it is only by retrospective analysis that the appropriate knowledge representation can be identified for resolving a particular problem at a particular point in time.

2.5.3 Metaphorical Reasoning

Koestler (1964) documented the use of metaphorical reasoning for creativity in the arts and sciences as the juxtaposing of two very different sets of ideas. Metaphorical reasoning involves using knowledge about the concepts and relationships in one domain, then mapping this knowledge to a target domain providing new insights into understanding the target domain. Research into metaphorical reasoning in artificial intelligence, and its subset analogical reasoning, have focused on understanding the mapping process between concept hierarchies in two well-structured domains, and the

power of these mappings (Gentner and Gentner 1983; Holyoak and Thagard 1989; Lakoff 1987; Lakoff and Johnson 1980; Lenat and Feigenbaum 1991; Mitchell 1993; Ortony 1993; Vosniadou and Ortony 1989).

In contrast, Schön's (1993) notion of generative metaphor uses the mapping process as the basis for negotiating meaning and creating structure in the target domain. Generative metaphors provide an initial structure for creating situated concept hierarchies in the target domain. People then negotiate the utility of these structures, deciding which concepts to include and which to leave out, possibly redescribing the concepts in the process. The result of applying a generative metaphor and negotiating meaning is a concept hierarchy in the target domain that can easily be used for metaphorical mapping between domains. Schön's notion is that generative metaphors enable people to see and reason about the real-world environment in new ways.

2.6 Computer Supported Cooperative Work

This section describes research in CSCW from a community of practice perspective and uses Jeff Conklin's and John Warfield's research to illustrate the approach.

2.6.1 Overview of CSCW

CSCW focuses on supporting work performed by groups in which individuals cooperate in some social and organisational context (Marca and Bock 1992). It articulates the nature of cooperative work and designs technological support through socio-technical design processes (Bannon and Schmidt 1991).

CSCW systems have been developed to produce an environment for participation including electronic team rooms (Nunamaker et al. 1991), videoconferencing, electronic bulletin boards and newsgroups, MUDs and MOOs, computer environments based on an "office building" metaphor (Madsen 1989), and computer environments that enable the flow of unstructured information such as Lotus Notes and GrapeVine. Support for the process of participation have been provided by Group Decision Support Systems (DeSanctis and Gallupe 1987), Group Support Systems (Jessup and Valacich 1993), and Electronic Meeting Support Systems such as GroupSystems (Nunamaker et al. 1991). The information requirements for groups are

supported by the notion of information domains (Hennessy 1991), and large virtual workspaces such as Rooms (Henderson and Card 1986) and chalkboards (Stefik et al. 1987) enable groups to manipulate this information. The flow of information between workers of a group can be modelled as a workflow system using techniques such as Activity Management (Benford 1991) as implemented in The AMIGO Activity Model (Danielson and Babatz 1988).

Individual CSCW systems have focused on providing a wide variety of support to particular aspects of both the participative and reificative aspects of cooperative work. A key concept in social worlds is that people's activity occurs in a socio-historical context. CSCW systems have focused on supporting social work but have not linked this work with the integrative meanings of the organisation. By failing to link the social work with the integrative meanings, it is difficult for people to reuse the products of this work in future situations.

2.6.2 CM/1

Jeff Conklin has been researching how computer support can be used to aid people socially reasoning about wicked problems (Conklin and Begeman 1989). A tool has been developed to support this social reasoning process and is called either gIBIS, CM/1, or QuestMap. The IBIS method underlies this social reasoning process and represents a conversation among the participants about a particular problem. The basic elements of IBIS are Issues, Positions and Arguments. People construct instances of these elements as they socially reason about the wicked problem. CM/1 enables people to graphically construct these elements, link them together and display them as hypertext nodes in a hypertext network. CM/1 enables people to construct a space for reasoning about a wicked problem. However, there is no support for reusing information across problems, or recognition that reasoning about wicked problems occurs in a socio-historical context.

2.6.3 Complex Situations

Interactive Management is a social process for dealing with complex situations and has been used in hundreds of situations since the early 1970s (Warfield and Cardenas

1994). It is a facilitated process that uses specially designed situation rooms and consists of three phases: the planning phase, workshop phase, and follow-up phase.

The planning phase identifies the people, information and facility requirements for the other two phases. In this phase, people scope the situation, and produce a White Paper that documents all that is currently known about the situation from the different perspectives involved.

The workshop phase has three elements: context, content and process. The context is provided by the scope statement. The content is provided by the participants by producing logical structures, or "maps", which reveal significant aspects of the situation of the alternatives invented for resolving the situation. The facilitator provides the process and employs a wide variety of techniques to enable the participants to produce the logical structures. Separate workshops may be conducted for defining the situation, designing alternatives and choosing an alternative for resolving the situation. Continuity of participation is assumed across these workshops. The follow-up phase is used either for iterating between the workshops, or for implementing the chosen solution.

Interactive Management is designed to support social worlds by enabling mutual engagement, creating shared intents, and constructing shared repertoire's in the form of logical structures. However, there is no explicit linkage between these shared intents and the organisation's integrative meanings, and there is no mechanism for reusing logical structures across situations.

Interactive Management is designed to be used when all other problem solving approaches have failed due to the complexity of the problem. By taking people out of their normal work environment into a carefully controlled problem-solving environment, Interactive Management enables people to focus on defining and solving their problems.

2.7 Summary

The real-world environment is socially constructed and is perceived by people as a dynamic, open system. People in organisations cope with this environment by socially

framing situations, extracting problems and performing activities. These situations are characterised as wicked problems. They are messy and inter-related in nature. These situations cannot be solved, they can only be resolved at a point in time.

As people have increasingly viewed the real-world environment as a dynamic, open system, their analytical units have evolved away from rational, task-based techniques, to more social techniques that reflect the ongoing negotiation of meaning. In this thesis, social worlds are the most appropriate analytical unit for understanding how organisations conceive situations. Ideally, communities of practice would be the most appropriate analytical unit, however, the joint strategic level of the ADF does not behave like communities of practice.

Organisations cope with the real-world environment by either reacting to it and adaptively learning, or being proactive and generatively learning. Both these forms of learning are social in nature, requiring the participation of people performing different roles, and may result in new strategies emerging which require the organisation to be redesigned.

Research into artificial intelligence has focused on well-structured problem-solving. The problems with this approach are perhaps typified by artificial intelligence research into metaphorical reasoning. Artificial intelligence research into metaphorical reasoning has focused on the mapping, or inference, process between two pre-defined, well-structured domains. Yet as Schön (1993) points out, the real value of metaphorical reasoning is the ability to generate new structures in the target domain. Schön's notion of generative metaphors provides a mechanism for coping with the open, dynamic nature of the real-world environment, whereas the artificial intelligence approach assumes a closed world.

3. A Theory of Framing

A mind that is stretched to a new idea never returns to its original dimensions --Oliver Wendell Holmes

Since life is growth and motion, a fixed point of view kills anybody who has one -- Brooks Atkinson

This chapter proposes a new theory of framing that describes how people in organisations conceive situations that change the ethos of an organisation. The underlying concept is that the activity of changing an organisation's ethos is external to the organisation. This activity involves negotiation between an organisation and other institutions. The boundary objects being constructed and negotiated during this activity are intents. The intents of an organisation describe a space which can be viewed as defining the activities an organisation is designed to perform. The ethos of an organisation is a subset of this space and defines the activities an organisation has externally negotiated to actually perform. The relationship between intents and the ethos of an organisation is shown in Figure 3.1. Changing the ethos of an organisation involves changing the shape of the space defined by an organisation's intents, and changing the subset of this space that the organisation has negotiated to perform. The theory of framing uses this space as the basis for describing how people in organisations use intents to conceive situations and construct new intents that may change an organisation's behaviour.

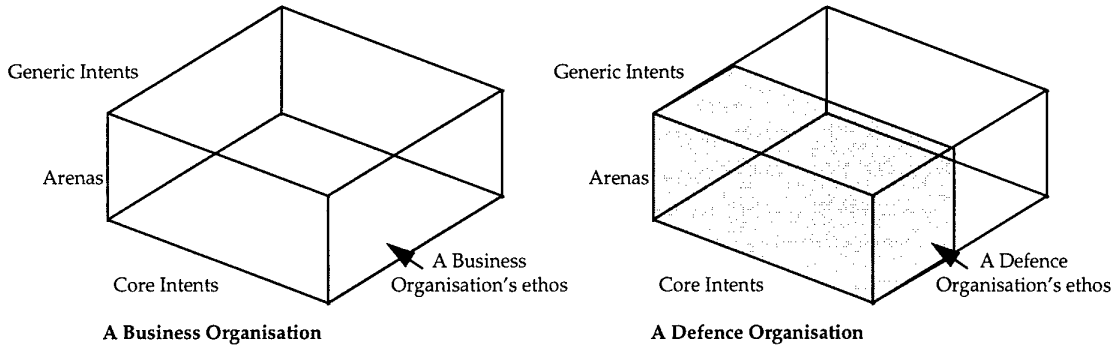

Figure 3.1 The relationship between intents and the ethos of an organisation for a business and a defence organisation

Two real-world case studies are used to demonstrate the theory of framing. This chapter is illustrated by a case study based on the ADF's involvement in the humanitarian disaster relief operation after volcanic eruptions at Rabaul in 1994. The disaster relief case study is used to demonstrate how the ethos of an organisation can be externally renegotiated to perform an activity the organisation is designed for, but is not currently performing. The second case study in Chapter Six is used to demonstrate how defining a new intent that changes the shape of the space describing an organisation results in realigning an organisation's structure and activity systems.

This chapter has four sections. The first section describes the disaster relief case study which is used to illustrate the concepts developed in the rest of the chapter. The second section shows how intents can define a space to describe an organisation by building this space to include roles, social worlds, arenas, and the ethos of an organisation. This space then provides the basis for describing how an organisation may change. The third section describes the theory of framing. Finally, the concept of intents is discussed and compared with research into goals in the knowledge-based systems approach. This discussion provides the basis for defining the requirements for computer support of the framing process.

3.1 Case Study

This section documents a case study based on the ADF's involvement in a humanitarian disaster relief operation after volcanic eruptions in Rabaul. The relationship between the ADF, the Australian government, and other government

departments is described, providing the organisational context for this case study. The nature of disaster relief situations is analysed by identifying why these situations can be viewed as wicked problems.

3.1.1 Organisational Background

The Australian government has many responsibilities. This section describes how the Australian government manages its relationships with other nations, manages its military forces, and manages disaster relief situations.

The relationship between the Australian government and some of the government departments is shown in Figure 3.2. The Minister for Foreign Affairs and Trade is responsible for managing Australia's relationships with other countries. The Minister exercises this responsibility through the Department of Foreign Affairs and Trade (DFAT). The two areas within DFAT relevant to this case study are the Australian International Development Assistance Bureau (AIDAB) and the Australian embassies. AIDAB is responsible for managing Australia's foreign aid program. The Australian embassies are responsible for maintaining the day-to-day diplomatic links with foreign countries and representing Australia's national interests in these countries.

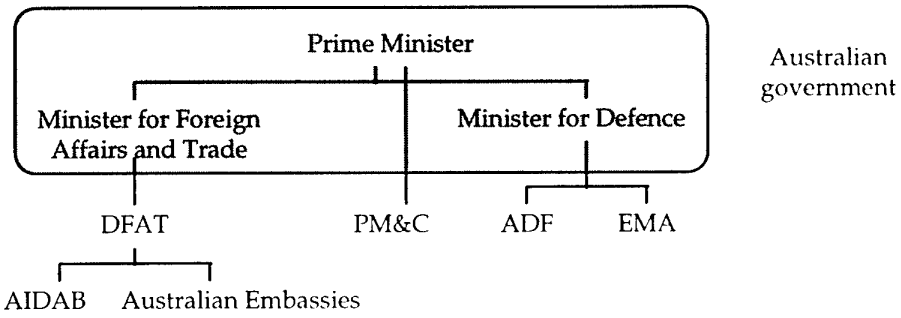

Figure 3.2 The Australian government and government departments

The Prime Minister and Cabinet's (PM&C) department is responsible for liaising with the Australian government to ensure a timely flow of information between the government and the people dealing with the situation.

The Minister for Defence is responsible for defending Australia's national interests. The Minister exercises this responsibility in two ways. Firstly, the ADF provides a

military capability for defending Australia's national interests. Secondly, Emergency Management Australian (EMA) is responsible for managing and coordinating natural disasters within Australia.

The areas of interest within the ADF for this case study are Headquarters Australian Defence Force (HQADF), Air Lift Group (ALG), and 1 Division. HQADF is responsible for conceiving situations from a military perspective, defining the situation and end-state, defining how the end-state will be achieved and the force structure required to achieve this end-state. ALG is responsible for operating C130 transport aircraft. 1 Division is an infantry unit that can be deployed at short notice. The roles of interest within HQADF are the Director of Joint Operations (DJOPS), Emergency Assistance Coordinator (EAC), Air Operations (AIROPS), Land Operations (LANDOPS), Maritime Operations (MAROPS), the Intelligence Officer (INTELLO), and the Watch Officer.

Responsibilities in disaster relief situations vary depending upon the nature of the situation. EMA are responsible for managing disaster relief situations in Australia with the ADF's support. AIDAB are responsible for managing disaster relief situations in foreign countries with both EMA's and the ADF's support. The ADF is responsible for managing any disaster relief situations in foreign countries where Australian nationals are threatened by non-natural causes. A contingency plan has been constructed by AIDAB, EMA and the ADF that formally specifies the roles of each of these organisations in a foreign disaster situation and the types of resources that may be required.

The case study will view the following organisations and institutions as social worlds: the Australian government, the Papua-New Guinea government, DFAT, AIDAB, Australian embassy in Papua-New Guinea, PM&C, EMA, ADF, HQADF, and ALG. Two further social worlds will be created during the case study: the disaster relief planning team, and the services-protected evacuation planning team. The following arenas will be used during the case study: HQADF, Meeting Room at AIDAB, AIDAB, ALG, EMA, House of Representatives Parliament House, HQADF Meeting Room, and DFAT. There are many more social worlds and arenas involved in this case study that have not been documented.

3.1.2 The Case Study as a Wicked Problem

Disaster relief situations are difficult to predict, control and define the outcomes. Responding to disaster relief situations often requires military involvement simply because these organisations have the types of capabilities required available at relatively short notice. Disaster relief situations in a foreign country are more complex. A military force cannot operate in another country without an official invitation from the government, otherwise it is an act of war. The government of any country must be seen to be safeguarding its own people and possessing the capability of doing so. Inviting a foreign country to assist in safeguarding its people will only be performed in "unusual" circumstances. Diplomatically, any formal invitation from a government asking another country for aid must be seen to be accepted to ensure that the government maintains its international standing. Therefore, any planning for these types of situations by other countries must be conducted informally, working on the basis of what could be done, and what is likely to be asked for. Under these circumstances where the natural, social, political and diplomatic conditions are vague and ambiguous, humanitarian disaster relief situations are wicked problems.

3.1.3 Volcanic Eruptions in Rabaul

The case study is documented in terms of the time and arenas in which activities are occurring, and the people representing institutions performing these activities.

Part I

Monday - 0715 at HQADF

> The Watch Officer monitoring the media notices a press report concerning "volcanic eruptions at Rabaul". The Watch Officer interprets this event as a possible humanitarian disaster relief situation in the south-west Pacific and sends the press report to EAC.
>
> EAC contacts AIDAB to check whether they have seen the press report. AIDAB confirm that they have seen the press report and that a meeting is being scheduled for 1100. EAC alerts DJOPS of the disaster situation and the possible requirement for ADF involvement. DJOPS reminds EAC that

there is another ADF operation being conducted in Papua-New Guinea and to be aware of resource scheduling conflicts and overlaps. EAC spends the next couple of hours studying the contingency planning document for disaster relief situations.

Monday - 1100 Meeting Room at AIDAB

EAC, AIDAB, PM&C and EMA attend the first disaster meeting convened by AIDAB. AIDAB ensures that all participants have the latest press releases about the Rabaul situation. It is quickly agreed that Australia may be asked by the Papua-New Guinea government to provide disaster relief aid to the people of Rabaul.

The participants then discuss the nature of the situation. The Rabaul population is estimated at 25,000+ and has been safely evacuated to nearby areas. The participants decide to task individuals to collect further information for the next meeting. AIDAB are assigned responsibility for collecting further information about the situation including the likely requirements of the Papua-New Guinea government, developing predictive models of further volcanic eruptions, and the requirements of the evacuated Rabaul population. EMA are assigned responsibility for determining the availability of disaster relief stores. EAC are assigned responsibility for determining the availability of transport aircraft. The participants agree to meet again at AIDAB at 1630.

Monday - 1300 at HQADF

EAC phones ALG to discuss the availability of transport aircraft for a possible disaster relief operation. ALG had already commenced monitoring the situation in Rabaul, aware that air transportation of disaster relief stores is a possible requirement. ALG raises the issue of whether Rabaul airfield is in a serviceable state given the nature of the volcanic eruptions.

EAC phones AIDAB requesting information about the status of the airfield at Rabaul. AIDAB agrees to find out this information through the Australian embassy.

Monday - 1300 at AIDAB

AIDAB communicates with the Australian embassy in Port Moresby requesting further information about the situation in Rabaul, the state of the volcanic eruptions, and the possible requirements for the evacuated population.

Monday - 1300 at EMA

EMA phones their stores depot in Dubbo to determine the amount of disaster relief stores and shelters available, and the availability of road transport for moving these supplies.

Monday - 1630 Meeting Room at AIDAB

EAC, AIDAB, PM&C and EMA attend the disaster meeting. AIDAB update the situation in Rabaul and then report that the latest estimates of the evacuated population are 40,000+ and that 60 tonnes of disaster relief stores are likely to be required by the Papua-New Guinea government. They also note that the airfield at Rabaul is unserviceable due to the volcanic activity and that the Australian embassy is assessing the suitability of a nearby airfield at Tokua.

EMA report that 60 tonnes of disaster relief stores are available, that road transportation is available at six hours notice, and that it would take ten hours to transport the stores to Richmond Air Force Base.

EAC confirmed that C130 transport aircraft are available, but obviously required an airstrip to operate. The meeting then discussed several other forms of transport. EAC stated that flying helicopters from Australia to Papua-New Guinea at short notice was impractical. An alternative of transporting the disaster relief by ship was dismissed due to time constraints.

The participants agree to continue their planning based on the assumption that Tokua airfield is available. The next meeting is scheduled for Tuesday at 1100.

Monday - 1830 at HQADF

EAC phones ALG to discuss the requirement of moving 60 tonnes of disaster relief stores. ALG determines that three C130 flights will be required to transport this disaster relief. The question for ALG is whether to schedule three C130 flights on one day or over multiple days. EAC agrees to take this issue to the next disaster meeting.

EAC writes a warning order formally notifying groups within the ADF that an operation may be required in the near future. It describes the situation, the type of operation and the resources that may be required. The warning order produced by EAC has wide distribution within the ADF, including to ALG.

Tuesday - 0930 at HQADF

EAC receives a fax from the Australian embassy via AIDAB describing the condition of the Tokua airfield. EAC faxes this information to ALG. A phone conversation between EAC and ALG determines that the airfield is serviceable for the short term for a number of C130 flights, but as there is no aircraft parking area, it would be impractical to operate more than one C130 flight per day into Tokua. EAC and ALG agree that the three C130 flights should be scheduled on three consecutive days.

Tuesday - 1100 Meeting Room at AIDAB

EAC, AIDAB, PM&C, and EMA attend the disaster meeting. AIDAB updates the situation in Rabaul. EAC states that the airfield at Tokua will be suitable for the disaster relief situation, but only one C130 flight per day will be able to operate into Tokua[1] due to parking restrictions. The participants agree that one C130 flight per day for three days will be

[1] For the rest of the case study, statements about flying to Rabaul, or conducting transport operations to Rabaul, in practice means flying to Tokua airfield near Rabaul.

satisfactory. AIDAB agrees to reimburse the ADF for the cost of these three C130 flights.

At this stage the participants have conducted as much planning as possible. They are now waiting for a formal request from the Papua-New Guinea government for disaster relief aid and for the Australian government to authorise the operation. AIDAB agrees to communicate with the Papua-New Guinea government via the Australian embassy stating that Australia is standing by to transport 60 tonnes of disaster relief in three C130 flights. The participants agree to schedule the next meeting when required.

Tuesday - 1500 at AIDAB

The Papua-New Guinea government formally requests 60 tonnes of disaster relief aid from the Australian government, and the Australian government agrees to supply this aid. AIDAB phones EAC, PM&C and EMA with this information and schedules a meeting for 1600.

AIDAB drafts a joint ministerial minute for the Minister for Foreign Affairs and Trade, and the Minister for Defence stating that Australian will supply 60 tonnes of disaster relief aid on three C130 flights starting Thursday.

Tuesday - 1515 at HQADF

EAC phones ALG and confirms that the disaster relief operation will commence on Thursday.

Tuesday - 1520 at ALG

The ALG mission schedulers remove three lower priority mission from the tasking board and schedule the disaster relief operation at the highest priority.

Tuesday - 1520 at EMA

EMA phones the road transport and stores warehouse at Dubbo requesting that the disaster relief stores be transported to Richmond as soon as possible.

Tuesday - 1600 Meeting Room at AIDAB

EAC, AIDAB, PM&C, and EMA attend the disaster meeting. AIDAB updates the situation in Rabaul. PM&C state that the Papua-New Guinea government has officially requested 60 tonnes of disaster relief aid and that the Australian government has agreed to supply the aid.

AIDAB distributes a document that formally states that the situation-specific intent of the disaster relief operation is to "provide humanitarian disaster relief to the people of Rabaul". EMA will transport 60 tonnes of disaster relief stores to Richmond by Thursday. The ADF will transport 60 tonnes of disaster relief stores from Richmond to Rabaul commencing Thursday, at the rate of one C130 flight per day for three days. All the participants agree to these strategies.

Tuesday - 1730 HQADF

EAC writes an operations instruction that authorises ALG to conduct three C130 flights to Rabaul in support of the disaster relief operation. This operations instruction is distributed widely within the ADF, including to ALG.

Wednesday - 0900 House of Representatives, Parliament House

The Minister for Foreign Affairs and Trade announces that Australia will be sending 60 tonnes of disaster relief stores to the people of Rabaul following the evacuation caused by volcanic activity.

Thursday - 1430 Meeting Room at AIDAB

EAC, AIDAB, PM&C and EMA attend the disaster meeting. AIDAB updates the situation in Rabaul. EAC states that the first C130 flight of disaster relief stores has arrived at Tokua airfield. PM&C organised a public relations exercise at Tokua airfield for the first C130 flight and wants to know why the C130 was only half-loaded when EAC had committed to three full C130 loads.

EAC stated that the three C130 flights were nominal flights for costing purposes. What had happened was that some of the disaster relief stores had arrived at Richmond when a C130 flight was scheduled to leave for Papua-New Guinea on a different mission. ALG decided to send some of the stores on this earlier flight with the aim of being seen to be responsive to the needs of the situation, and knowing that in the final analysis three and half C130 flights of disaster relief stores would be flown to Rabaul instead of the nominal three flights.

The outcome of this discussion was that EAC would keep PM&C better informed of how the operation was conducted in future.

Friday - 0800 AIDAB

AIDAB receives an electronic message from the Australian embassy stating that the disaster relief stores have been stolen and a request from the Papua-New Guinea government to transport 60 law enforcement officers to Rabaul. AIDAB faxes the message to EAC, PM&C and EMA, and then phones each of the participants scheduling a meeting for 0900.

Friday - 0900 Meeting Room at AIDAB

EAC, AIDAB, PM&C and EMA attend the disaster relief meeting. AIDAB updates the situation in Rabaul, the problems with the disaster relief stores being stolen, and the Papua-New Guinea government request to transport 60 law enforcement officers to Rabaul.

The aim in this situation of "providing humanitarian disaster relief to the people of Rabaul" was clearly not being achieved. However, the disaster relief contingency plan used by the ADF in this situation has a constraint of not transporting military or law enforcement personnel. After much discussion it was agreed that as an emergency measure, one C130 flight of 60 law enforcement officers would be flown to Rabaul, and that this flights would not contravene the legal constraints on the ADF conducting operations in a foreign country.

Friday - 1100 HQADF

EAC phones ALG informing them of the need to transport 60 law enforcement officers from Port Moresby to Papua-New Guinea. ALG contacts the C130 in-flight to Rabaul and informs the pilot of the new mission.

EAC writes an amendment to the operations instruction, formally stating the need to transport the 60 law enforcement officers. The operations instruction is distributed widely within the ADF, including ALG.

Saturday - 1600 Meeting Room at AIDAB

EAC, AIDAB, PM&C and EMA attend the disaster meeting. AIDAB updates the situation in Rabaul. EAC informs the meeting that the disaster relief stores and 60 law enforcement officers have been successfully transported to Rabaul. As there are no more requests for assistance, the participants agree to end the situation.

Part II - The following is a hypothetical chain of events that replaces the events on the Friday and Saturday to illustrate the implications of reconceiving situations. These events are based on actual series of events that have occurred in Cambodia and Somalia.

Friday - 0800 HQADF

A press release is received by the Watch Officer stating that there are unconfirmed reports of a military insurgency threatening the lives of Australian nationals in the Rabaul area. The Watch Officer sends the press release to EAC.

EAC briefs DJOPS on these latest developments. DJOPS decides to form a planning team investigating a services-protected evacuation. EAC is tasked with finding out from the Australian embassy the latest situation in Rabaul, the Papua-New Guinea government's response, and to ask the crew of today's C130 disaster relief flight to find out as much as they can whilst at Tokua airfield.

EAC phones AIDAB checking that they are aware of the latest developments and asking for further information from the Australian embassy. A meeting is scheduled for 1100 to discuss the situation.

EAC phones ALG and requests that the C130 crew collect information about the military insurgency in Rabaul and to report back as soon as possible.

Friday - 0900 HQADF Meeting Room

The participants in the services-protected evacuation are AIROPS, LANDOPS, MAROPS, INTELLO, DFAT, and PM&C. EAC is invited to brief the meeting on the disaster relief situation, the status of the volcanic eruptions, the location and state of Tokua airfield, and the location and number of Australian nationals in the area.

The INTELLO briefs the meeting on the military insurgency, the locations where the guerillas appear to be operating, and the locations of the Australian nationals whose lives have been threatened. The INTELLO outlines the likely aims of the guerillas and their likely targets. Further discussion then centre on the suitability of Tokua airfield for a services-protected evacuation and the ability to move the Australian nationals to the airfield. At this point, EAC is asked to leave the meeting.

PM&C states that the Papua-New Guinea government currently considers the events in Rabaul as looting and that the local police force will handle the situation.

PM&C is tasked to make sure the Australian government keeps the Papua-New Guinea government aware of all developments in Rabaul, and to push for a services-protected evacuation as soon as possible. The INTELLO is tasked with finding the specific sites of operations by the guerillas. DFAT is tasked with liaising with the Australian embassy to determine the exact number of Australian nationals, where they are located, how to get all of them to Tokua airfield, and the time required to move them. A contingency plan exists for services-protected evacuation that outlines the

types of resources that may be required and the factors that must be taken into account. AIROPS, LANDOPS, and MAROPS are tasked with constructing a plan for safely evacuating an anticipated 45 Australian nationals from Tokua. The next meeting is scheduled for 1500 hours.

Friday - 1100 HQADF

AIROPS phones ALG alerting them of the latest developments in Rabaul and the potential need for two C130s at very short notice.

LANDOPS phones 1 Division army unit in Townsville and alerts them to the potential situation and the need to deploy at four hours notice.

AIROPS, LANDOPS and MAROPS begin detailed planning, and issue a warning order.

Friday - 1100 DFAT

DFAT conducts a phone conversation with the Australian embassy about the situation in Rabaul, the sites of the Australian nationals, evacuation plans, and the Papua-New Guinea government's current response to the situation.

Friday - 1100 AIDAB Meeting Room

EAC, AIDAB, PM&C and EMA attend the disaster meeting. EAC brings the meeting up-to-date with the latest developments in Rabaul and the fact that the second C130 disaster relief flight is due to land at Tokua airfield. After some discussion, EAC confirms that if the services-protected evacuation is approved, then the disaster relief operation will be terminated.

Friday - 1200 HQADF

ALG faxes EAC the C130 flight crew report on the situation in Rabaul. Guerilla attacks are becoming more frequent, centred around the local plantations.

EAC immediately takes the report to AIROPS.

AIROPS faxes the report to DFAT and PM&C. During a phone conversation with PM&C, AIROPS is informed that the Australian government will request the Papua-New Guinea government to authorise the services-protected evacuation as soon as possible due to the recent developments in Rabaul.

Friday - 1500 HQADF Meeting Room

AIROPS, LANDOPS, MAROPS, INTELLO, DFAT and PM&C attend the services-protected evacuation meeting. The INTELLO outlines the latest activities by the guerillas. DFAT confirms that there are 45 Australian nationals in the area and that they can be assembled at Tokua at four hours notice. AIROPS outlines the proposed services-protected evacuation operation. The situation specific intent for the operation is to "conduct a services-protected evacuation of the Australian nationals from Rabaul". The strategy for the operation is for two C130s to transport 60 troops from 1 Division to secure Tokua airfield, and then evacuate the Australian nationals. A new joint organisation structure has been created for this operation. A joint commander will command a detachment of 60 troops from 1 Division and a detachment of two C130s from ALG for the duration of the operation.

DFAT reports that the Papua-New Guinea government is currently reconsidering the situation.

Friday - 1800 HQADF

PM&C phones DJOPS advising that the Papua-New Guinea government has approved the services-protected evacuation operation and the Australian government has authorised this operation. DJOPS immediately informs AIROPS.

AIROPS phones ALG and instructs them to conduct the mission immediately, whilst LANDOPS phones 1 Division and informs them to be ready to move.

AIROPS writes and distributes an operations instruction formally authorising the operation.

LANDOPS writes a ministerial minute for the Minister of Defence outlining the current events in Rabaul, the suspension of further disaster relief aid, the nature of the services-protected operation, and stating that 45 Australian nationals will be evacuated to safety.

3.2 Representing an Organisation

The case study documents how the activity of conceiving a situation may change an organisation's behaviour. During the case study the ADF's behaviour evolved from "maintaining a military capability" to "maintaining a military capability and conducting a disaster relief operation", then to "maintaining a military capability and conducting a services-protected evacuation", and finally back to "maintaining a military capability" when the operations were completed.

The activity of changing the ADF's behaviour was external to the ADF's current activity systems. In Part I of the case study, changing the ADF's behaviour required negotiation between EAC representing the ADF, AIDAB, EMA, PM&C, the Australian government, and the Papua-New Guinea government. In Part II of the case study, changing the ADF's behaviour required negotiation between the ADF, DFAT, PM&C, the Australian government and the Papua-New Guinea government.

The ADF's behaviour changed upon approval of the disaster relief operation, and changed again for the services-protected evacuation operation. These changes in behaviour resulted in realigning the ADF's activity systems and structure of the organisation.

This section describes a language for representing an organisation. The notion of intents and the ethos of an organisation are defined to enable the relationships between an organisation and other institutions to be understood. These intents define a space for describing an organisation. This space is used to show the relationship between intents, roles, social worlds, arenas, and the ethos of an organisation. Defining the ethos of an organisation in terms of this space provides the basis for describing the different ways in which the ethos of an organisation may change.

3.2.1 Intents

Intents were defined by the Scholastics in the Middle Ages as something "that points outside itself to something else" (Audi 1995, p381). They are boundary objects that represent how an activity system or organisation relates to other activity systems or institutions. Intents are the product of people negotiating between activity systems or institutions. In response to new events in the real-world environment, intents may be reconceived and redescribed through a negotiation process. Descriptions of intents may evolve over time and are ephemeral in nature.

This notion of intents is illustrated by comparing the descriptions of the purpose of two logistic organisations who conduct the same type of business. The first logistic organisation described their purpose as "a quality logistic organisation". The logistic organisation could rationally define what this purpose means without reference to any other institution and is similar to the concept of intentions used in agent-oriented research (Bratman 1987) and goals in well-structured problem-solving (Newell and Simon 1972). The second logistic organisation described their purpose as "quality logistic support to flying operations". Defining what this purpose means requires negotiation with the flying organisation to determine what the flying requirements are, what the logistic requirements are, and what it means to logistically support a flying organisation. The relationship between the logistic and flying organisations will always be subject to renegotiation as events in the real-world environment unfold. Therefore, any description of this purpose will always be incomplete and will "point outside itself" to the relationship between the organisations. In these terms, the purpose for the second logistic organisation is an intent.

An intent may be articulated in two ways: the intent may have a name and the intent may be described in a number of forms including contingency plans, models, and standard operating procedures. For example, the intent of the ADF is named "defending Australia's national interests". This intent is described in a number of ways including: articulating what the concept "Australia's national interests" means; models of how Australia's national interests may be attacked; and contingency plans which describe how the ADF would respond to different types of attack. Four types of intents

are described in this thesis: generic intents, core intents, situation-specific intents and reasoning intents.

3.2.1.1 Generic Intents

Generic intents represent the purpose of the organisation and name the different types of situation in which other institutions expect an organisation to be involved. They are ongoing and have no final goal state. An example of a generic intent for the ADF is "the defence of Australia's national interests".

Generic intents can be organised into a generic intent hierarchy. The highest-level intent, or root node, represents the main purpose of the organisation. Figure 3.3 shows an example of a generic intent hierarchy for the ADF. It can be seen that the second-level of generic intents are derived by describing the concept of Australia's national interests, and modelling how these interests may be threatened.

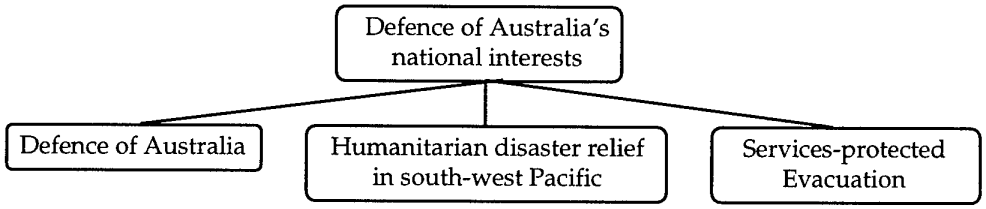

Figure 3.3 A generic intent hierarchy

Generic intents are generative metaphors for framing situations. For example, using the generic intent of "humanitarian disaster relief in the south-west Pacific" in the case study means that the situation is viewed in terms of the physical environment being temporarily unsafe. Events in Rabaul are interpreted in terms of: are the people in a safe location; do they have shelter, food, and water; is there adequate sanitation facilities and aid distribution networks. Strategies for resolving this situation are phrased in terms of safeguarding the people until the physical environment settles down. The strategies employed in the case study were transporting disaster relief stores to the people of Rabaul, and transporting law enforcement officers to ensure the aid was distributed to the people.

In contrast, the military insurgency in the case study resulted in the "services-protected evacuation" generic intent being used to reframe the situation. Applying this

generative metaphor meant that the situation was no longer viewed in terms of the physical environment being temporarily unsafe. Instead, the political and social environment was viewed as being indefinitely unsafe. Events in Rabaul are reinterpreted in terms of: what is the aim of the guerillas; what are their likely targets; where have the guerillas been operating; where are the Australian nationals; and can the Australian nationals be safely moved to an airfield or port for evacuation. Strategies for resolving this situation are still expressed in terms of safeguarding the people. But now its safeguarding the people by removing them from the indefinitely unsafe political and social environment. The strategy employed in the case study was to evacuate the Australian nationals under the ADF's protection to a stable environment.

3.2.1.2 Core Intents

Core intents represent instruments that are used under direction. For example, the ADF is an instrument that the Australian government directs to pursue national intents. Similarly, capabilities in the ADF, such as strike and transportation, are instruments that are directed by ADF personnel to pursue situation-specific intents.

An organisation's core intents can be manifested in multiple ways. For example, in the case study the core intent transportation was described in terms of C130s, helicopters, and ships.

An organisation's core intents may be perceived in different ways in different types of situations. For example, an army can be perceived as having the capability of defeating an enemy's army. An army can also be perceived as having a large number of personnel available at very short notice who are trained in handling crisis situations and are therefore suitable for disaster relief operations and peacekeeping operations.

An organisation's core intents may be reconceived and redescribed through the process of "SEEING-AS". For example, Spitfire aircraft are normally classified as fighter aircraft. During the invasion of Europe by the Allies in 1944, Spitfires were reconceived as transport aircraft for carrying barrels of beer on modified bomb racks for the return journey to the forward air bases in Normandy after major maintenance work in England (Johnson 1957, p216).

3.2.1.3 Situation-Specific Intents

Situation-specific intents situate generic and core intents by describing the purpose of an organisation in a situation. Constructing a situation-specific intent involves negotiating with other institutions and may involve changing the ethos of an organisation. Situation-specific intents are boundary objects that are used to construct an activity system for the situation by coordinating existing activities across organisations and activity systems. Situation-specific intents are then used by organisations to internally align their activity systems and organisation structures to the needs of the situation. Situation-specific intents are manifested as strategies that may evolve as the situation evolves. The relationship between generic intents, situation-specific intents and strategies is shown in Figure 3.4.

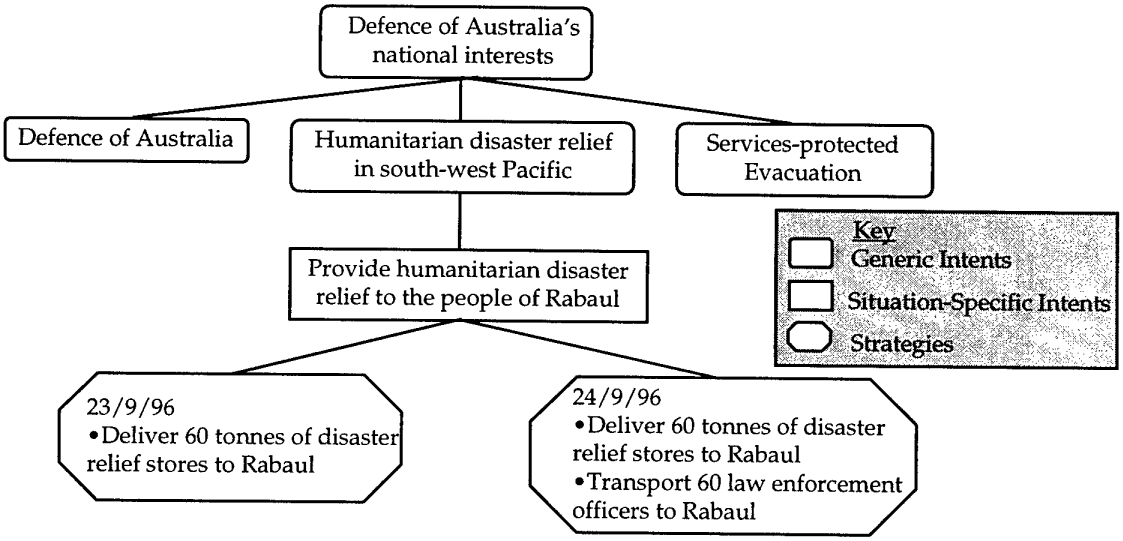

Figure 3.4. Generic intents, situation-specific intents, and strategies

For example, in the case study the ADF interpreted the volcanic eruptions in Rabaul by using the generic intent "humanitarian disaster relief in the south-west Pacific" to frame the situation. Negotiations with AIDAB, EMA, and PM&C produced the situation-specific intent "provide humanitarian disaster relief to the people of Rabaul". This situation-specific intent was initially manifested as the strategy "deliver 60 tonnes of disaster relief stores to Rabaul". This strategy was used by each of the organisations to internally align their activities and coordinate their activities with the other

organisations. For example, EMA planned and performed the activity of transporting 60 tonnes of disaster relief store to Richmond by road transport. ALG scheduled and performed the activity of transporting the 60 tonnes of disaster relief stores from Richmond to Rabaul in three C130 flights.

The case study also details how the strategies that describe a situation-specific intent may evolve as events in the real-world environment unfold. These strategies do not evolve locally within an activity system. Instead, the strategies evolve by negotiation between organisations and activity systems. The negotiation process involves reinterpreting the situation-specific intent and redefining the strategies that describe the situation-specific intent. For example, in the case study the situation-specific intent "provide humanitarian disaster relief to the people of Rabaul" was initially manifested as the strategy "deliver 60 tonnes of disaster relief stores to Rabaul". Subsequent events included the disaster relief aid being stolen, and a request from the Papua New Guinea government to transport 60 law enforcement officers to Rabaul. The situation-specific intent was reinterpreted by a negotiation process involving EAC, AIDAB, EMA, and PM&C resulting in the additional strategy of transporting "one C130 flight of 60 law enforcement officers to Rabaul".

3.2.1.4 Reasoning Intents

Reasoning intents represent the purpose of the activities performed, and models constructed, during a situation in relation to other activities being performed. Reasoning intents are used to ensure that optimisation within a local activity system does not deoptimise the performance of the organisation's other activity systems, or the situations in which the organisation is acting.

For example, in the case study PM&C organised a public relations exercise at Tokua airfield for the first C130 flight expecting a fully loaded C130, but finding only a half-loaded aircraft. ALG's decision to send some of the disaster relief stores on an earlier flight had been made on the basis of being seen to be responsive to the situation. However, this decision failed to coordinate the additional C130 activity with the other activities being conducted for the operation. Resolving this problem required further negotiation across the activity systems. One solution was for the ADF to keep all the

participants informed as to how the operation was being conducted, enabling any changes to be related to other activities being performed.

3.2.2 Ethos of an Organisation

> "... The Watch Officer interprets this event as a possible disaster situation and sends the press report to EAC. EAC contacts AIDAB ..."

Organisations do not exist in isolation. They are the product of a complex web of political, economic, legal, social and regulatory factors. Understanding how people in organisations behave requires an understanding of how organisations are expected to behave by other institutions.

The ethos of an organisation describes how an organisation is expected to behave by other institutions. An organisation's ethos may be articulated as a set of values, responsibilities, constraints and intents. For example, AIDAB's ethos includes that it has the intent to "provide aid to foreign countries", that it has responsibilities to "manage natural disaster situations in foreign countries from an Australian perspective", and that it is constrained politically in defining which countries receive aid, and financially by the amount of aid that can be provided within its budget. The ADF's ethos includes that it has the intent to "defend Australia's national interests", that it has responsibilities to aid people in the south-west Pacific in disaster situations, and that it is constrained to only performing actions that maintain a military capability in peacetime (Strategic-Review 1993).

There are three ways of viewing the ethos of an organisation: external, internally explicit, and internally implicit. The description of AIDAB's ethos in the previous paragraph describes how AIDAB wants it behaviour to be seen externally by other institutions. An organisation's external ethos is a subset of its internally explicit ethos. The internally explicit ethos of an organisation will also include strategies for aligning the organisation, competing with other organisations, and optimising the use of an organisation's resources. For example, in the case study the ADF's external ethos was to transport the 60 tonnes of disaster relief stores as three C130 loads to Rabaul. The ADF's internally explicit ethos modified this strategy to optimise the use of its C130 resources and transported an additional half load, taking advantage of an earlier C130

flight to Papua-New Guinea. An organisation's internally implicit ethos reflects the way an organisation actually behaves and is the view a customer has after dealing with the organisation.

The ethos of an organisation represents the relationship between an organisation and other institutions. These relationships exists in a political, economic, legal, social and regulatory framework. For example, the concept of AIDAB "managing disaster relief situations in a foreign countries from an Australian perspective" implies that there are relationships between AIDAB and other institutions. There will be relationships between AIDAB and their suppliers, transport organisations, Australian government, other Australian government departments, foreign governments, foreign government departments, and other aid organisations. Relationships also exist with the legal system about what constitutes aid and how it can be supplied, the political system in terms of who gets aid, and the economic system for determining the price of aid.

In the case study, "EAC contacts AIDAB" because EAC understands that in disaster relief situations there is a potential relationship between the ADF and AIDAB. EAC's understanding is based on both the ADF's external ethos and AIDAB's external ethos for how these organisations will act in disaster relief situations. This relationship may simply be in the form of providing transportation, or it may involve other expertise including engineers, sanitation or communications support. The nature of this potential relationship is partly specified in the disaster relief contingency plan, but the actual relationship, and the behaviour of the organisations, can only be described in terms of an actual situation.

The concept of an organisation's ethos representing the relationship between an organisation and other institutions can be used to understand why AIDAB and EAC were not participants in the services-protected evacuation social world. AIDAB were not participants because there was no potential relationship between the ADF and AIDAB for a services-protected evacuation activity based on the ADF's external ethos and AIDAB's external ethos. EAC was not a participant because there was no need to form a relationship between the ADF and other emergency assistance organisations, which is the basis of EAC's role.

Changing an organisation's ethos requires renegotiating the relationship between the organisation and other institutions. For example, the case study documents how conducting the disaster relief operation and the services-protected evacuation involved changing the ADF's ethos by relaxing the constraint that the ADF only maintains a military capability. Changing the ADF's ethos to enable it to conduct these operations required renegotiating the ADF's ethos with both the Australian government and the Papua-New Guinea government. The initial change to the ADF's ethos was that the ADF was authorised to conduct three C130 disaster relief missions to Rabaul between the Thursday and Saturday.

3.2.3 Using Intents to Describe an Organisation

Generic intents and core intents are orthogonal ways of describing an organisation as shown in Figure 3.5. These intents define a space for representing an organisation in two ways. Firstly, these intents represent the different types of relationships between an organisation and other institutions. Secondly, these intents are used to align the structure and activities of an organisation. This section describes how this space is used to define the relationships between intents, roles, social worlds and arenas. This space is used to describe the ethos of an organisation, and how this ethos may change. Finally, the concepts of situations, activities and models is articulated.

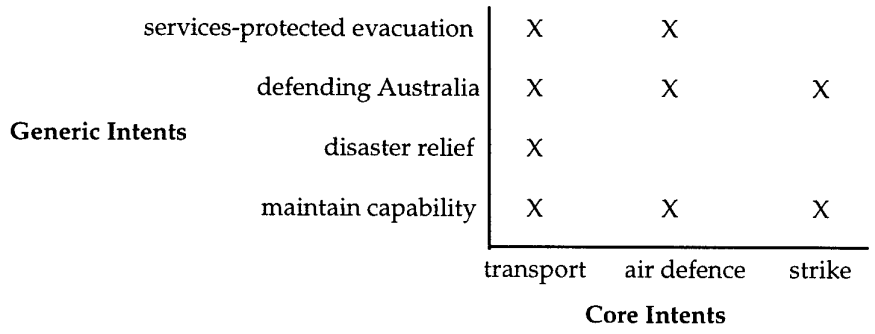

Figure 3.5 An orthogonal view of an organisation

The space defined by the generic intents and core intents of an organisation may not be fully populated. For example, Figure 3.5 shows an organisation where the core intent of "strike" has no meaning in "disaster relief" type situations.

3.2.3.1 Roles

Roles are responsible for intents in organisations as shown in Figure 3.6. For example, in the ADF EAC is responsible for the generic intent "humanitarian disaster relief in the south-west Pacific", Commander Air Lift Group (CdrALG) is responsible for the core intent "air transport" and Commander Australian Theatre (COMAST) may be responsible for "services-protected evacuation". Roles may also be responsible for relationships between generic intents and core intents in a situation. For example, in the case study a joint commander is responsible for conducting the services-protected evacuation of Australian nationals from Rabaul and is assigned two C130 aircraft and 60 troops to conduct this operation.

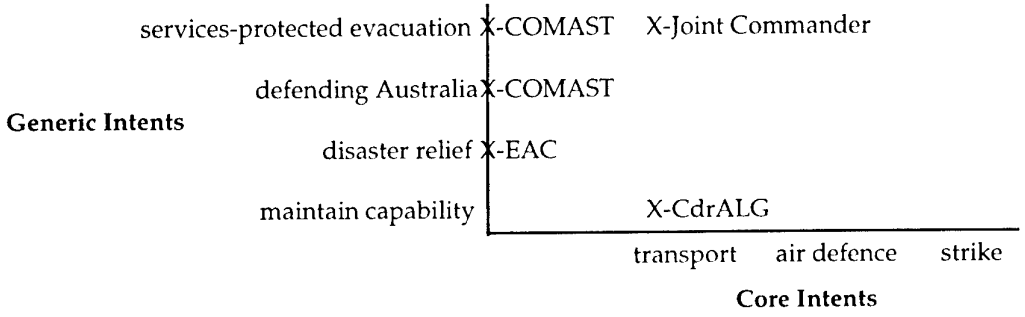

Figure 3.6 The relationship between roles and intents in an organisation

3.2.3.2 Social Worlds

Social worlds in organisations may be formally created in two ways as shown in Figure 3.7. Social worlds may form from people doing a similar type of work for a core intent, for example, ALG is a social world. A social world may also form from working together on a manifestation of a generic intent, for example, the disaster relief planning team and the services-protected evacuation planning team in the case study are examples of social worlds. These two forms of social worlds are also orthogonal. A social world derived from a core intent will cut across many social worlds for manifestations of generic intents. A social world derived from a generic intent will cut across many social worlds for core intents.

Social worlds may also be informally created and have no relationship to the formal organisation structures and activities. For example, social worlds may form from

hobbies, interests and other non-work related activities. Social worlds may also span organisations on both a formal and informal basis. For example, in the case study the disaster relief planning team is a social world that spans the ADF, AIDAB, EMA and PM&C.

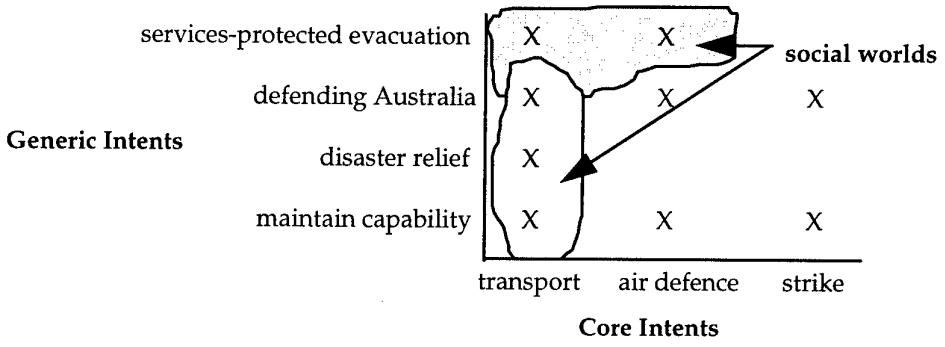

Figure 3.7 The relationship between social worlds and intents in an organisation

3.2.3.3 Arenas

Different types of arenas are designed to enable roles to perform different types of activities in an organisation as shown in Figure 3.8. At the strategic level of an organisation, these arenas enable an organisation to negotiate with other institutions and change the ethos of an organisation. For example, in the case study the meeting rooms at AIDAB and HQADF were arenas for negotiating a shared understanding of the situation in Rabaul, and constructing a situation-specific intent. At the tactical level of an organisation, arenas enable the execution of strategies. For example, in the case study the airfields at Richmond and Tokua were arenas designed to enable air transportation operations.

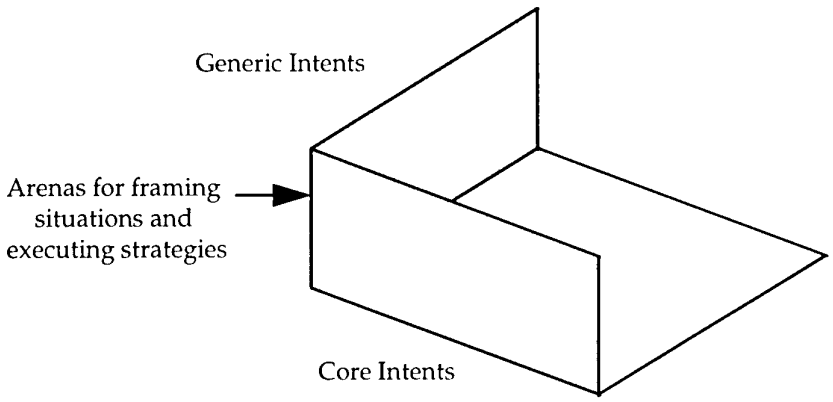

Figure 3.8 The relationship between arenas and intents in an organisation

3.2.3.4 Ethos of an Organisation

The ethos of an organisation describes how other institutions expect an organisation to behave. O'Brien (1997) has identified a fundamental difference between business and defence organisations. A business organisation uses its core intents to perform all its generic intents on a day-to-day basis. Defence organisations are different. In peacetime, defence organisations do not conduct warfare. Instead, they maintain the capability for conducting warfare. Thus a defence organisation only performs a negotiated fraction of the generic intents it was designed to perform on a day-to-day basis. The distinction between a business organisation and a defence organisation is shown diagrammatically in Figure 3.9.

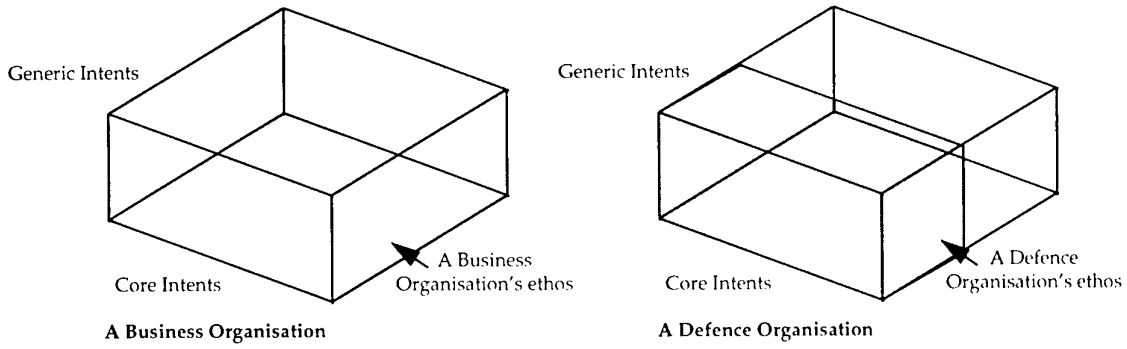

Figure 3.9 A comparison between a business organisation's ethos and a defence organisation's ethos

3.2.3.5 Types of Changes to the Ethos of an Organisation

Changing the ethos of an organisation involves redefining the space described by the generic intents and core intents of the organisation. The underlying notion is that intents are flexible, dynamic representations that are reconceived as the real-world environment changes. Reconceiving intents and changing the ethos of an organisation is a negotiated activity with other institutions and is external to the organisation's activity systems. Figure 3.10 shows how the space describing an organisation and the ethos of an organisation can be transformed by adding new generic intents, adding new core intents, and by negotiating to perform the generic intents for which the organisation was designed but is not currently performing.

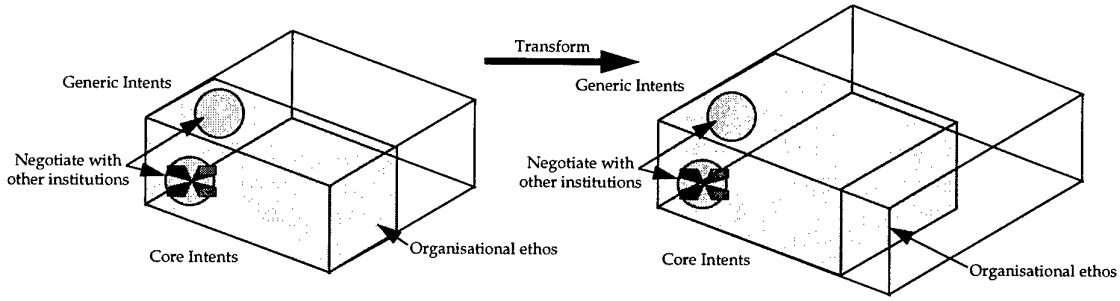

Figure 3.10 Changing an organisation's ethos

The ethos of an organisation can expand within the space describing the organisation to include generic intents that the organisation is designed for, but is not currently performing. For example, in the case study the ADF's ethos expands to perform the generic intents "disaster relief" and "services-protected evacuation".

Secondly, the manifestations of the core intents for the organisation can be redescribed through the process of "SEEING-AS" (Schön 1993). Redescribing an organisations manifestations of core intents may lead to reconceiving the generic intents of the organisation. For example, the army provides the capability of conducting land-based operations to militarily defeat the enemy. An army can be reconceived by "SEEING-AS" a large number of people well-trained in handling crisis situations. Reconceiving the manifestation of the core intent in these terms leads to the insight that the army can be used in traditionally non-military operations such as disaster relief and peacekeeping operations. Defining new generic intents for disaster relief and

peacekeeping operations then leads to an investigation of the different requirements for conducting these operations such as the notion that there is no "enemy", and the need to collaborate with other institutions rather than "commanding". The result of this process is a different shaped space for describing the organisation.

Thirdly, a new generic intent can be defined for the organisation or the existing generic intent can be reconceived. These new generic intents change the shape of the space that defines the organisation and often requires new core intents. For example, the large scale use of information technology systems in the business world has resulted in an economic dependence on these systems. This dependence has been recognised by reconceiving the generic intent of "defending the nation's interests" to include these systems. Developing contingency plans for this generic intent has resulted in a new core intent called "information warfare" which has properties of both defending a nation's information technology systems, and attacking other nation's information technology systems.

Fourthly, a new type of core intent can be defined or the existing core intents can be reconceived. The new core intents change the shape of the space that defines the organisation and often provide the basis for conceiving the new generic intents. For example, the introduction of electronic switching in the telecommunications world enabled switching to be handled more efficiently. With the advent of electronic switching came the realisation that telecommunication companies could start selling a whole new range of products such as the "1-800" and "13" numbers that exploited the electronic switches ability to be rapidly reprogrammed. A telecommunication company's generic intents are now not only defined in terms of providing a telecommunications infrastructure but also in terms of value added services that exploit this infrastructure.

3.2.3.6 Situations

Situations are conceptual constructs (Dewey 1938) that evolve and are reinterpreted as activities are performed in the real-world environment. Situations are constructed by interpreting the real-world environment and determining which set of "facts" are

deemed to be relevant. These interpretations, or descriptions, are dependent upon the intents people use to conceive the situation.

3.2.3.7 Activities

Organisations design their activity systems to enable them to use their core intents to achieve generic intents. For example, the core intent transportation can be manifested as air transport and road transport. The activity systems for air transport include aircraft maintenance scheduling, mission scheduling, aircrew scheduling, and load scheduling.

3.2.3.8 Models

Models are a simplified description of the world and provide the basis for action. Different types of models are constructed whilst reasoning about a situation including: descriptive models that describe people's understanding of the situation, and predictive models that define how the real-world environment may change and the courses of action people may consider. These types of models are used to describe the individual and shared framing knowledge representations. The different models constructed on both an individual and shared basis may be conceived from different intents.

The framing process results in people determining the basic-level concepts for the situation, constructing framing concept hierarchies, and selecting the relevant facts for instantiating the model in the situation. *Framing concept hierarchies* are constructed by people defining categories for the basic-level concepts in the situation.

Models are constructed for different purposes when framing situations compared to resolving situations. In framing, models are constructed as an aid for, and an output of, human reasoning and are used to communicate ideas about the situation. Using models to resolve situations may involve constructing computational models for determining the situation.

3.3 The Framing Process

Framing is the process people in organisations perform to conceive situations and construct intents. It is a form of inquiry for action (Dewey 1938; Schön 1993) that

enables people to assign meaning to their real-world experience (Watzlawick, Weakland, and Fisch 1974) and create a perspective for viewing the real-world environment.

The framing process in organisations involves people negotiating a shared understanding of the situation. This shared understanding can be described by constructing framing knowledge representations. *Framing knowledge representations* consist of descriptive and prescriptive models, situation-specific intents, and strategies that are constructed as people negotiate about the situation. Constructing framing knowledge representations involves conceptualising things in the real-world environment, articulating concepts by giving them names, and organising these concepts into framing concept hierarchies. This conceptualisation process identifies the basic-level concepts (Rosch et al. 1976) for acting in the situation. Framing is more than naming basic-level concepts. It also involves identifying the relevant political, economic, social and regulatory factors for the situation. These factors require negotiation to enable relationships between institutions and activity systems to be established, and to enable changing an organisation's ethos when required.

Constructing framing knowledge representations is often a difficult process because different members of the framing social world initially frame the situation in different ways. Overcoming these differences requires articulating the facts being used to frame the situation by each individual, understanding the generative metaphors used to frame the situation, and then negotiating about these differences. For example, in Part II of the case study, the Australian government frames events in Rabaul as a military insurgency threatening the lives of Australian nationals, whereas the Papua-New Guinea government frames these events as looting. The consequences of these different interpretations is that the Australian government wants to conduct a services-protected evacuation whereas the Papua-New Guinea government believes the local police force can handle the situation. Resolving these differences required an understanding of the types of events that the Papua-New Guinea government would accept as inconsistent with looting, then to task agencies to collect information about the situation specifically looking to see whether these types of events were occurring.

Framing knowledge representations are the outputs of the framing process and are used as boundary objects to construct an activity system for the situation that coordinates and aligns activities across institutions and activity systems.

The framing process is always incomplete. As people frame situations, they can then start acting in the situation. Acting in the situation provides new information which may require people to reinterpret the way they frame the situation.

The framing process has three stages as shown in Figure 3.11: recognising a situation, reasoning about a situation, and resolving the situation. This section uses the case study to illustrate each of these stages, then discusses how to recognise the end of a situation, and the role of feedback loops.

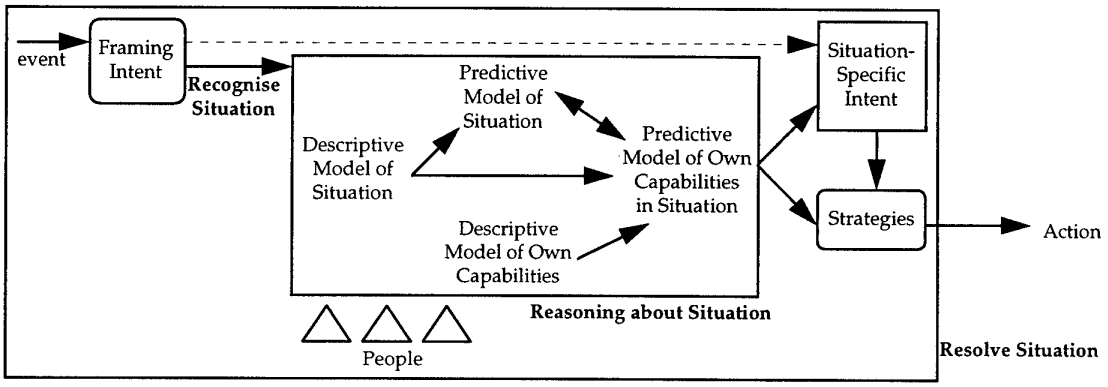

Figure 3.11 The framing process

3.3.1 Recognising a Situation

Recognising a situation occurs when people use their generic intents and core intents to interpret events in the real-world environment and frame situations. The generic intent or core intent used to frame the situation is called a *framing intent*. For example, in the case study the Watch Officer at HQADF uses the generic intent "humanitarian disaster relief in the south-west Pacific" to interpret the press report about "volcanic eruptions at Rabaul" as a possible disaster relief situation.

The process of framing situations in organisations requires negotiation within an activity system, across activity systems, and sometimes across institutions. Starting a negotiation process requires defining the initial membership of the social world

framing the situation, negotiating responsibilities, and defining the arena in which the situation will be framed by the social world. The membership of the framing social world requires people from different activity systems and institutional social worlds who can bridge between social worlds in order to construct framing knowledge representations that articulate a shared understanding of the situation. Inviting other institutions to participate in a framing social world is based on an understanding of the institution's ethos, and the recognition that a relationship between institutions may be required in the situation. For example, in the case study "EAC contacts AIDAB" precisely because EAC understood that in a disaster relief situation there is a possibility of a relationship between AIDAB's and the ADF's activities, and that these activities needed to be coordinated.

Descriptions of intents have three roles in recognising a situation. Firstly, these descriptions may define the initial membership of the framing social world, an initial allocation of responsibilities, and the arena in which framing will occur. Secondly, the descriptions may be generative metaphors that define a way of thinking about the situation. Thirdly, these descriptions may define a set of basic-level concepts that serve as a starting point for constructing framing knowledge representations. For example, the generic intent "humanitarian disaster relief in the south-west Pacific" was used to frame the disaster relief situation in Part I of the case study. A description of this intent, in the form of a contingency plan, outlined the membership of the social world as EAC, AIDAB, PM&C and EMA, that AIDAB had overall responsibility for disaster relief operations in foreign countries, and therefore that AIDAB would provide the arena for framing these situations. The initial situation from EAC's perspective is shown in Figure 3.12. This contingency plan was a generative metaphor stating that the natural environment was temporarily unsafe and that the aim was to safeguard the people until the environment settled down. The contingency plan defined basic-level concepts such as: air transport, disaster relief supplies, communications, engineering support, and health services support that provide the basis for constructing framing knowledge representations.

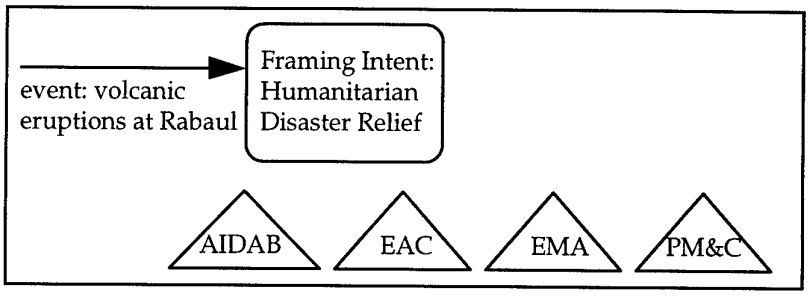

Figure 3.12 Framing the example from EAC's perspective

The framing process may occur within the existing ethos of an organisation, or it may change the ethos of an organisation. Framing situations within the ethos of an organisation is a simpler process because a richer set of descriptions of the framing intent will have been constructed and regularly used as part of the organisation's day-to-day activities. In contrast, framing situations that change the ethos of an organisation is often characterised by a lack of useful descriptions of the framing intent. As a result, more effort is spent in determining the appropriate membership of the framing social world, negotiating responsibilities, finding a shared generative metaphor, negotiating a set of basic-level concepts, defining an activity system for the situation that coordinates activities across existing institutions and activity systems, all of which results in a shared understanding of the situation. For example, conducting air transport operations in the ADF is a well-defined activity that occurs on a day-to-day basis and requires little negotiation between the activity systems involved. In contrast, conducting peacekeeping operations for the ADF is far more complex because the descriptions for this framing intent are still being developed.

3.3.2 Reasoning about a Situation

Reasoning about a situation involves constructing shared framing knowledge representations that are used as boundary objects to coordinate activities across activity systems and institutions, and to align activities and structures within an organisation. These framing knowledge representations are constructed as people in the framing social world negotiate about the situation. For example, in the case study descriptive models are constructed of the situation in Rabaul and the locations of the evacuated population. Predictive models are constructed for how the situation in

Rabaul may evolve and possible courses of action such as the requirement to transport 60 tonnes of disaster relief stores which could be addressed by transporting the stores by road from Dubbo to Richmond, then by air from Richmond to Rabaul. The situation-specific intent for the disaster relief situation was to "provide humanitarian disaster relief to the people of Rabaul" and included the strategy "EMA will transport 60 tonnes of disaster relief stores to Richmond by Thursday". The models, situation-specific intents and strategies are shown in Figure 3.13.

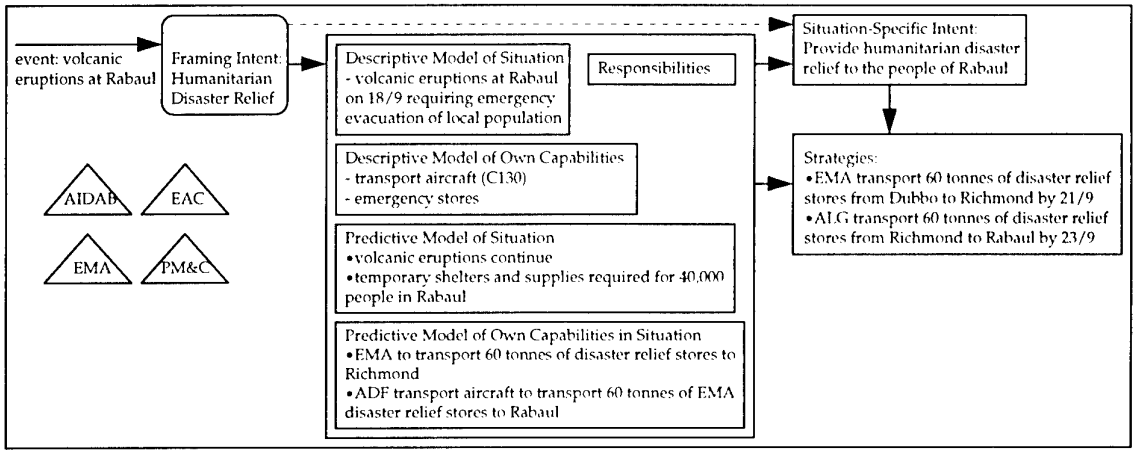

Figure 3.13. Developing the volcanic eruptions in Rabaul situation

Reasoning about a situation is an iterative, improvisatory process that may require continual changes to the framing knowledge representations. These changes result from people being tasked to find particular information, then discovering that finding this information requires other issues to be addressed. As a result, the basic-level concepts may be redefined and recategorised into new framing concept hierarchies changing the language for reasoning about the situation. For example, in the case study EAC was tasked to determine the availability of transport aircraft. An informal conversation between EAC and ALG found this information but also elicited the issue of whether the airfield at Rabaul was serviceable. One possible outcome of this new information may have been that transport aircraft were unsuitable for operating into Rabaul and that the concept of "transportation" would need to be redescribed as "sea transport" or "helicopters".

The informal negotiation process across institutions and activity systems occurs in parallel with formal mechanisms within an organisation. For example, EAC informally discusses with ALG the possible requirement for transport aircraft and then follows-up with a warning order that alerts all of the ADF of the possibility of conducting a disaster relief operation and the resources that may be required.

3.3.3 Resolving a Situation

The situation-specific intent is a boundary object that is constructed by the framing social world to coordinate and align work across institutions and activity systems. The strategies that describe a situation-specific intent define an activity system for resolving the situation that spans existing activity systems and organisations. The situation-specific intent and strategies are then used by an organisation to internally align its structures and activity systems. The organisation can then execute the strategies to resolve the situation. For example, the situation-specific intent in Part II of the case study is to "conduct a services-protected evacuation of the Australian nationals from Rabaul". The ADF chooses to dynamically create a new joint organisation structure to deal with this situation.

The strategies can be viewed as the inputs into an organisation's existing activity systems. In these terms, a strategy defines the requirements for well-structured problem-solving within an activity system. However, this approach fails to recognise the importance of the interconnections between activity systems and institutions that were negotiated during the framing process. For example, in the case study ALG chooses to reinterpret the strategy of "transport 60 tonnes of disaster relief stores from Richmond to Rabaul" by making use of an additional half-loaded C130 that was flying to Papua-New Guinea for a different operation. The problem that arose was that PM&C organised the press to meet the first C130 flight into Rabaul, which happened to be the half-loaded C130. The press then wanted to know why the C130 was not fully loaded, a question PM&C were unable to answer from the information available to them. The problem would not have arisen if ALG had informed PM&C of the changes to the number of C130 flights. PM&C would then have been in a position to either

answer the press' questions, or they could have rescheduled the press for the first fully-loaded C130 flight.

3.3.4 Recognising the End of the Situation

Recognising the end of the situation involves people perceiving that the situation-specific intent has been accomplished for the situation. The easiest way of recognising the end of the situation is the successful execution of all the specified strategies. However, this assumes that the specified strategies adequately achieved the situation-specific intent, and that no new events have occurred that alters the way the situation is conceived and described as a situation-specific intent. Ultimately, recognising the end of the situation requires all the members of the framing social world to agree that the situation-specific intent has been accomplished for the situation.

Members of the framing social world representing different institutions may disagree as to whether the situation has been resolved. The subsequent negotiations may surface underlying differences in how different members conceive the situation. These differences will either be resolved by negotiation, or some of the members may choose not to participate in the situation any further. For example, the United Nations peacekeeping operation in Somalia was originally conceived to provide humanitarian disaster relief. When the strategies were achieved, there was a debate about the future of the peacekeeping operation. The Australian government conceived peacekeeping as providing temporary support to the people of a nation. In contrast, the American government conceived peacekeeping more broadly to include establishing and maintaining peace. For these reasons, the ADF returned home after the initial strategies were achieved, whereas the American military stayed in Somalia to perform a new set of strategies.

3.3.5 Feedback Loops

The dynamic, open systems nature of the real-world environment requires feedback loops as a mechanism for incorporating change into the framing process. These changes may manifest themselves as new events and new understandings of the situation which alters the way the situation is conceived, described and resolved, and

changes the membership of the social world framing the situation. The framing and solving activities are inter-related. As people execute strategies to resolve the situation they may elicit new information that changes the way the situation is framed, which may change the strategies that need to be performed.

Part II of the case study describes how a situation may be reconceived using a different framing intent due to new events in the real-world environment. The situation in Rabaul is initially conceived by the ADF using the "humanitarian disaster relief in the south-west Pacific" generic intent. Reports of a military insurgency in Rabaul result in the Australian government reconceiving this situation using the generic intent "services-protected evacuation". Reconceiving the situation requires a different set of basic-level concepts, different models to be constructed, a different situation-specific intent, and different strategies to achieve this situation-specific intent. The services-protected evacuation situation was reconceived by a different social world to that used for the disaster relief situation.

Reconceiving a situation is viewed quite differently by organisations and individuals. The following example is based on the case study. From an organisational perspective, the ethos of the ADF was renegotiated to conduct a disaster relief activity then renegotiated again to conduct a services-protected evacuation activity. Changing the ethos of the ADF involved transforming the framing knowledge representations and activity system established for the disaster relief situation into a different framing knowledge representation and activity system for the services-protected evacuation. Instead of relating activities across AIDAB, EMA, PM&C, ADF, Australian government, and the Papua-New Guinea government for the disaster-relief activity, a different set of activities are now related across DFAT, ADF, Australian government and the Papua-New Guinea government. This transformation process occurred externally to the ADF, and externally to the disaster relief activity system in which the ADF was acting.

The individuals involved viewed this transformation process quite differently. For those individuals involved in the disaster relief social world, their activity terminated when the situation was reconceived. For those individuals involved in the services-

protected evacuation social world, their activity commenced when the ethos of the ADF was renegotiated.

3.4 Discussion

This section discusses the relationship between intents and meta-planning, examines the implications for decision support and agent-oriented research, compares the theory of framing with situated action approaches, and finally identifies requirements for computer support to the framing process.

3.4.1 Meta-Planning

This section examines the relationship between meta-planning and intents, and shows how intents are used as boundary objects by people to interpret the use of, and results from, a planning system.

Research into meta-planning focuses on planning about planning (Davis 1976; Stefik 1980; Wilensky 1980; Wilensky 1981). Meta-planners reason about both the adverse interactions, and positive interactions, between plans for achieving different goals. The underlying assumption is that it is possible to pre-define the types of interactions between plans, and that the meta-planner can reason about these interactions within the planning system.

The case study describes an interesting problem that highlights the meta-planning approach and distinguishes the role of intents from the role of goals. The ADF was assigned the strategy of flying 60 tonnes of disaster relief stores from Richmond to Rabaul. This was negotiated as three C130 flights. ALG decided to take advantage of an earlier half-loaded C130 flight to Papua-New Guinea for a different operation, to transport an additional half-load of disaster relief supplies to Rabaul. PM&C scheduled the press to meet the first C130 flight which happened to be the additional half-loaded C130 flight. This led to many questions about why Australia was not sending more supplies.

ALG's scheduling behaviour can be understood from a meta-planning perspective by applying the meta-theme "don't waste resources" to optimise the use of resources

across plans. From a C130 scheduling perspective, this optimised the use of the C130 aircraft and achieved all the extant goals.

The problem occurred in this situation because C130 scheduling was not an independent planning activity, but was inter-related with other activity systems such as PM&C scheduling the press. ALG's scheduling activity was more complex than simply scheduling C130s. This activity involved three stages as shown in Figure 3.14. The first stage required people to map the requirements of the situation to the representation used in the scheduling system. The second stage required the scheduling system to produce an optimal set of plans. The third stage involved people interpreting these plans for their ability to satisfy the requirements of each situation and their interactions with other activity systems. If the plans are inadequate, then the requirements need to be represented in a different way in the scheduling system, and be rescheduled. Given this analysis of ALG's scheduling activity, the problem in the case study arose because the plans were not interpreted in terms of their interaction with other activity systems.

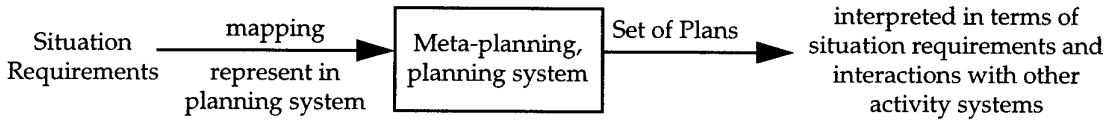

Figure 3.14 The planning activity as a three stage process

The essential difference between an intent such as "defending Australia's national interests" and a meta-theme such as "don't waste resources" is a reflection of the differences between an open system and a well-structured problem-solving system. Intents are designed to support human activity systems and represent the fluid nature of these systems. In contrast, the meta-planning approach is designed to operate within automated systems, requiring a well-structured domain. A meta-theme is conceived in a certain manner, with a pre-defined set of behaviours and a pre-defined set of functions for operating with planning objects. An intent is ephemeral in nature, it is conceived in a certain manner at a point in time, but can be reconceived as the real-world environment changes. Intents provide the basis for conceiving situations

and negotiating relationships between activity systems, resulting in the definition of behaviour in a situation, and the definition of relationships between planning objects.

3.4.2 Decision Support and Agents

This section examines a model of decision support and questions the utility of this model for representing discontinuous learning, and then discusses the implications for agent-oriented research.

Hackathorn and Keen (1981) define three distinct, but related, categories of decision support. Individual decision support focuses on supporting the decisions made by an individual acting autonomously. Group decision support focuses on supporting the decisions made by people within a social world working on separate, but highly inter-related activities. Organisational decision support focuses on supporting the decisions made by people representing different social worlds to achieve organisational goals. Organisational decision support systems (ODSS) require the ability to access individual decision support systems, group decision support systems, and construct boundary objects for relating the different activities within the organisation.

Hackathorn and Keen's model can be viewed as describing the different types of decision-making that occur within an existing system. For example, Section 3.2.1 describes the purpose of two logistic organisations as "a quality logistic organisation" and "quality logistic support to flying operations". Hackathorn and Keen's model can be used to describe decision-making for the first logistic organisation. However, this model provides no insight into how the second logistic organisation is able to reconceive its intents by renegotiating its relationship with other institutions because this activity is external to Hackathorn and Keen's model.

A simplistic way of handling the requirements of the second logistic organisation would be to define a fourth layer in Hackathorn and Keen's model called "inter-organisational support" that would be concerned with conceiving situations and renegotiating relationships between institutions. However, this approach fails to address the problem encountered with C130 scheduling described in Section 3.4.1 where relationships between activity systems are required at the group support level. Taking this a step further, it can be argued that the concept of individuals acting

autonomously within an organisation is meaningless, at the very least these individuals are consuming some organisational resource.

An alternative approach to handling the requirements of the second logistic organisation would be to recognise that the current notions of decision-making and decision support are constrained by working within an existing system. The theory of framing describes how intents can be used as the basis for conceiving situations, how conceiving situations may involve renegotiating the types of relationships between institutions and activity systems, and how intents are constructed and used as boundary objects for coordinating activities across activity systems. In order to develop intelligent systems, the capability needs to be developed to enable computer systems to conceive situations in new ways and negotiate new relationships with other activity systems outside of the computer systems' initial knowledge.

The implications for artificial intelligence is that current techniques are inadequate for handling change that is negotiated externally to the existing activity system. For example, agent-oriented research is neatly described by Hackathorn and Keen's model. Much of the agent-oriented research has focused on developing autonomous agents, there is increasing research in the field of distributed artificial intelligence which can be described mainly at the group decision support level with the organisational decision support level starting to be investigated. Whilst the agent-oriented approach enables the development of systems with more complex behaviour, a paradigm shift is required to develop artificial intelligence systems that can negotiate change externally to it's activity system, then realign the activities of the activity system to reflect those changes.

3.4.3 Situated Action

This section distinguishes between the situated action approach to improvisatory behaviour and the improvisatory behaviour that emerges from people framing situations. The key distinction is that improvisatory behaviour in the situated action approach arises within an activity system, whereas improvisatory behaviour in the theory of framing results in new relationships between activity systems.

Situated action approaches focus on describing how problematic situations arise during human activity and the improvisatory behaviour that emerges (Suchman 1987). In this approach, plans are resources for orienting people in a situation, rather than pre-defined solutions.

The case study describes an interesting problem where the Papua-New Guinea government requested 60 law enforcement officers be transported to Rabaul after the first load of disaster relief stores was stolen. The situated action approach would describe the subsequent chain of events as an example of improvisatory behaviour.

However, the disaster relief contingency plan used by the ADF has a constraint that law enforcement personnel will not be transported during the conduct of a disaster relief operation. The Papua-New Guinea government request is not a problematic situation that arises during human activity. Rather, it questions how the situation has been framed, whether performing a disaster relief activity is the appropriate activity to be performing. There are three ways of addressing this issue. The Papua-New Guinea government's request can be turned down. However, this means that the situation-specific intent is not being achieved. Secondly, the situation can be reframed using a different framing intent. Thirdly, the ADF can enter into negotiations with the Australian government and Papua-New Guinea government to drop the constraint for this particular situation. The last two responses both require negotiation external to the activity system in order to determine what to do inside the activity system.

3.4.4 Requirements for Support Framing

The theory of framing identifies new requirements for representing knowledge in a computer system as follows:

- The process of framing involves the construction of framing knowledge representations. Constructing framing knowledge representations involves constructing new types of concepts, models and intents.
- Concepts, models and intents may have multiple descriptions.
- The process of framing can be considered as the process of disambiguating conflicting descriptions of a concept, model or intent. During the framing process,

multiple descriptions of a concept, model or intent may exist in a single context with no lifting rules defined for disambiguating these descriptions.

3.5 Summary

This chapter presented a theory describing how people in organisations conceive situations that change the ethos of an organisation. It argued that generic intents and core intents are orthogonal views of an organisation that define a space for representing an organisation. These intents are the basic building blocks for describing how an organisation's ethos is viewed by other institutions, and for structuring and aligning an organisation's activity systems.

Changing the ethos of an organisation involves reshaping the space defined by the organisation's generic intents and core intents. This space can be reshaped in four ways including performing a generic intent the organisation is designed for but is not currently performing, redescribing a core intent, defining a new generic intent, and defining a new core intent.

The activity of changing the ethos of an organisation is external to the organisation and requires negotiation with other institutions. The boundary objects constructed during these negotiations are framing knowledge representations in the form of models, situation-specific intents and strategies. These framing knowledge representations define an activity system for the situation that is used to coordinate activities across institutions and activity systems, and to internally align an organisation's structure and activity systems for the situation.

The theory of framing presented in this chapter describes how an organisation's intents are used as the basis for conceiving situations and constructing new intents that may change an organisation's behaviour. Descriptions of intents have three roles in the framing process: they define the social worlds for framing, they may be used as a generative metaphor for thinking about the situation, or they may define a set of basic-level concepts as the basis for constructing framing knowledge representations. Situations framed within the ethos of an organisation will have richer descriptions of the framing intent than situations framed outside the ethos of an organisation because the organisation will be performing these types of situations on a day-to-day basis.

Therefore, situations framed within the ethos of an organisation will spend less time determining the membership of the framing social world, and determining the appropriate generative metaphor and basic-level concepts for reasoning about the situation.

4. Knowledge Representations for Supporting Framing

The map is not the territory. --Alfred Korzybski

This chapter presents a set of sixteen framing elements that are used to construct framing knowledge representations for a situation during the framing process. These elements represent "business objects" that people use to frame situations. The framing knowledge representations are incorporated into an organisation's corporate memory, which is characterised as an accumulating pool of knowledge representations. Multiple knowledge representation techniques are required to support framing including hypertext (Conklin 1987) and frames (Minsky 1975). The author has devised a third knowledge representation technique called descriptive networks to handle the notion that a concept may have many descriptions, and that multiple descriptions of a concept may co-exist in a single context whilst people negotiate the meaning of this concept. The sixteen elements are described, and how they may be used to support the framing process is shown. The chapter concludes with a discussion of problems in knowledge representation.

4.1 Accumulating Pool of Knowledge Representations

The process of framing situations results in people constructing, and reasoning about, framing knowledge representations. Different people participating in the framing process will have different ways of viewing the real-world environment and thus construct different framing knowledge representations. These representations may be inconsistent and incompatible. People use these framing knowledge representations as the basis for negotiating shared framing knowledge representations that describe the social world's shared understanding of the situation. Constructing a framing knowledge representation involves applying intents metaphorically, selecting and naming new concepts, constructing descriptions of concepts or reusing existing descriptions, and constructing framing concept hierarchies.

The underlying concept for supporting framing is an accumulating pool of knowledge representations. The pool of knowledge representations comprises both an historical record of situations and the current situations of interest to the organisation. New framing knowledge representations are continually being accumulated as the people within the organisation adapt to changes in the real-world environment and frame new situations. These framing knowledge representations may be inconsistent with other knowledge representations in the pool of knowledge representations. Integrating the framing knowledge representations with the generic, prototypical knowledge representations in the pool of knowledge representations requires a reflective process.

The pool of knowledge representations can be viewed, and accessed in multiple ways. People view the pool of knowledge representations in terms of the roles they have performed and the situations they have worked in. The pool of knowledge representations is a historical basis for viewing how a role has been performed in different types of situations. A conceptual view of the pool of knowledge representations reveals how concepts are manifested, or described, in different ways in different situations by different people.

Instantiating an element as part of the framing process in constructing representations for a situation also involves creating contextual linkages. These linkages link the element to both organisational and situational contextual information. These linkages enable the pool of knowledge to be viewed in different ways.

The pool of knowledge representations is only ever partially constructed. The nature of framing wicked problems requires new types of abstractions, new descriptions of abstraction, and new instances of elements to be created whilst constructing framing knowledge representations, and these representations are continuously added to the pool of knowledge representations.

4.2 Knowledge Representations Techniques

Chapter 3 identifies models and intents as the key artifacts for framing. In constructing and reasoning about models for a situation, people often use unstructured knowledge representations as a starting point for understanding the situation, then add structure as their understanding increases. Thus the requirement for knowledge representation

techniques is the ability to construct representations of unstructured information, structured information that enables an abstraction to have multiple descriptions, and contextual knowledge during the framing process. Three knowledge representation techniques are used to support the construction of situated knowledge representation's during framing: hypertext, frames and descriptive networks. Descriptive networks are the author's knowledge representation technique for representing abstractions with multiple descriptions. This section presents an overview of the techniques, Section 3.3 documents the primitives that implement these techniques, and Section 3.4 shows how the primitives may be used as templates for constructing situated representations.

4.2.1 Hypertext

Hypertext is a knowledge representation technique for enabling people to navigate through unstructured information (Conklin 1987). It consists of a set of text documents where the text contains machine-supported links to specific text locations either within the same text document, or in another document.

4.2.2 Frames

Minsky (1975) defined frames as data structures for representing stereotypical situation. A frame is a "chunk" of knowledge. It contains attributes which are always true in situations, and slots which contain specific instances of data about the situation.

The concept of frames will be somewhat modified in this thesis. Frames will be used for chunking contextual information for an element. Each frame has a set of slots. Each slot is expected to be filled by a set of instances of a particular type of element. In this manner, frames provide no stereotypical information about the situation. Instead, the slots in frames are a meta-representation (Davis 1976) that provide information about the type of elements required to instantiate the slot, and thus providing the ability to interlink information in the pool of knowledge representations.

4.2.3 Descriptive Networks

Descriptive networks are the author's knowledge representation technique for supporting the distinction between the name of an abstraction and the description of an abstraction. They support the notion that an abstraction may have many

descriptions. These descriptions may be constructed for different situations, different people in a situation, or by an individual at different points in time as they gain new insights about a situation. There is no limit on the number of descriptions of an abstraction that can co-exist in a single context. The process of framing is about negotiating the meaning of the abstraction from these multiple descriptions. Three types of description networks are described in this thesis: concept description networks, model description networks, and intent description networks.

Descriptive networks are similar to Lakoff's (1987) notion of radial structures. A radial structure consists of a central case that describes an idealisation of the concept, and the subcategories are derivations from the central case. For example, the concept "mother" may have a central case described as a mother who is and always has been female, and who gave birth to the child, supplied her half of the child's genes, nurtured the child, is married to the father, is one generation older than the child, and is the child's legal guardian. The subcategories of mother include: stepmother, adoptive mother, birth mother, natural mother, foster mother, biological mother, surrogate mother, unwed mother, and genetic mother. Each of these subcategories deviate from the ideal in some manner.

The difference between descriptive networks and radial structures is that descriptive networks do not have an ideal descriptive case. Instead, the name of the abstraction is used to represent the notion that the abstraction itself is the central case, and all the descriptions of the abstraction are sub-categories.

4.2.3.1 Concept Description Networks

Figure 4.1 illustrates a concept description network. The root node "Class" is the abstraction from which all concepts are created. The second level contains the concept names, for example, "weapon system", "transport", and "general stores". The third level contains the descriptions of the concept. These descriptions contain the attributes for a concept in a particular situation and provide the templates for instantiating a concept. In this manner, it can be seen that a concept has a number of instances, each of which was created from a different description and therefore has a different set of attributes.

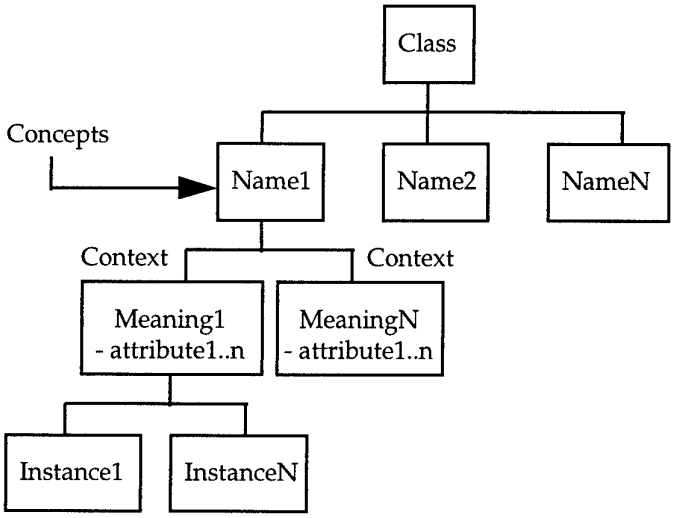

Figure 4.1 Concept description networks

4.2.3.2 Model Description Network

Figure 4.2 illustrates a model description network. The root node "Model" is the abstraction from which all models are created. The second level contains the model names, for example, "aircraft transportation", "aircraft loading", and "aircraft scheduling". The third level contains the model descriptions. These descriptions contain the attributes for a model in a particular situation. These attributes are concept descriptions. These descriptions provide a template for instantiating the model. Instantiating a model description may involve constructing framing concept hierarchies, and assigning values to the leaf-node concepts in these hierarchies. Framing concept hierarchies are constructed by using each of the attribute concept descriptions as a root node, then linking further concept descriptions to the attribute and constructing a hierarchy.

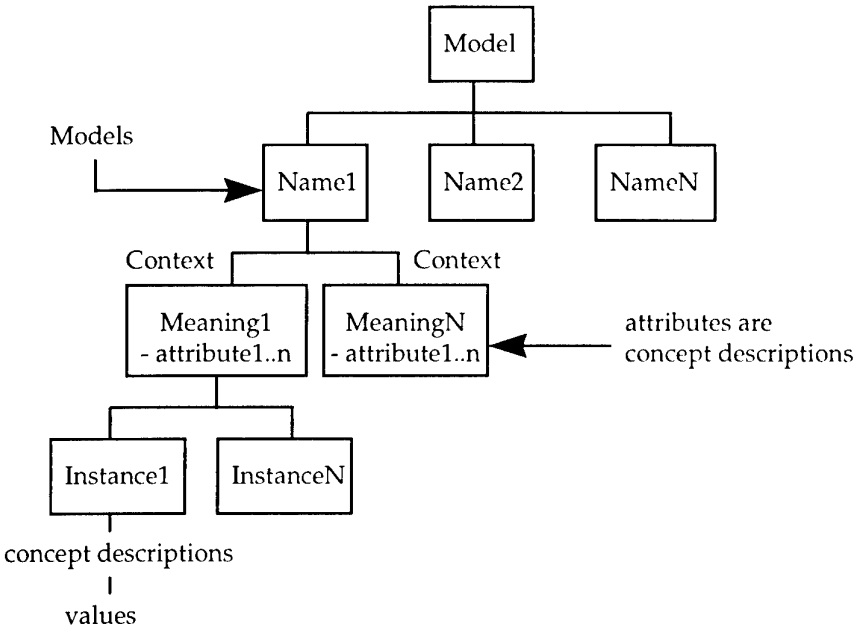

Figure 4.2 Model description networks

The ability to construct concept hierarchies in this fashion enables people to find the appropriate categorisation of concepts for the current situation and to define the basic-level concepts for social reasoning in the situation. The basic-level concepts are the leaf nodes of the concept hierarchies, and often may be the attributes of the model.

4.2.3.3 Intent Description Networks

Figure 4.3 illustrates an intent description network. The root node "Intent" is the abstraction from which all intents are created. The second level contains the different types of intents, that is, generic intents, core intents, situation-specific intents, and reasoning intents. People conceptualise, reason about, and use these intents in different ways. The third level contains the intent names, for example, defending Australia's national interests, provide humanitarian disaster relief aid to the people of Rabaul. The fourth-level contains the intent descriptions. These descriptions are realised as model descriptions. Generic intents and core intents apply these descriptions as generative metaphors. Descriptions for situation-specific intents and reasoning intents are the result of applying generative metaphors and social reasoning about the situation. The fifth level contains instantiations of the descriptions of the

intent. Core intents, situation-specific intents and reasoning intents have instantiations. Generic intents are only instantiated by using a generic intent to frame a situation, situating the generic intent as a situation-specific intent, then describing and instantiating the situation-specific intent.

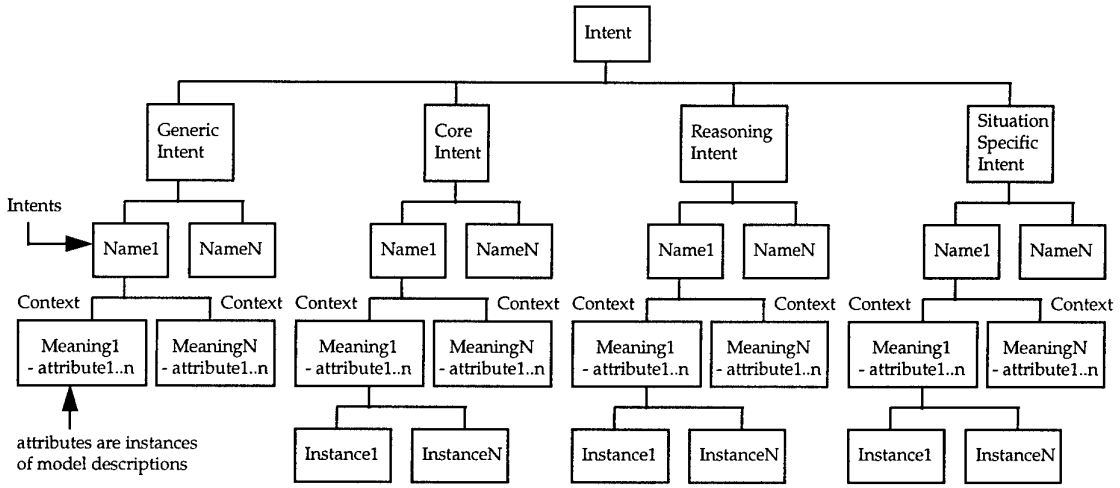

Figure 4.3 Intent description networks

4.3 Elements for Constructing Situated Knowledge Representations

This section presents the sixteen elements used in this thesis for constructing situated knowledge representations during the framing process. The sixteen elements are: activities, concepts, core intents, generic intents, individuals, links, models, organisations, patterns, players, reasoning intents, roles, situations, situation-specific intents, statements and strategies. Figure 4.4 shows some of the linkages between these sixteen elements. This figure only shows the internal representation of knowledge in the computer. It doesn't reveal any information about the framing knowledge representations that are constructed during the framing process using these elements.

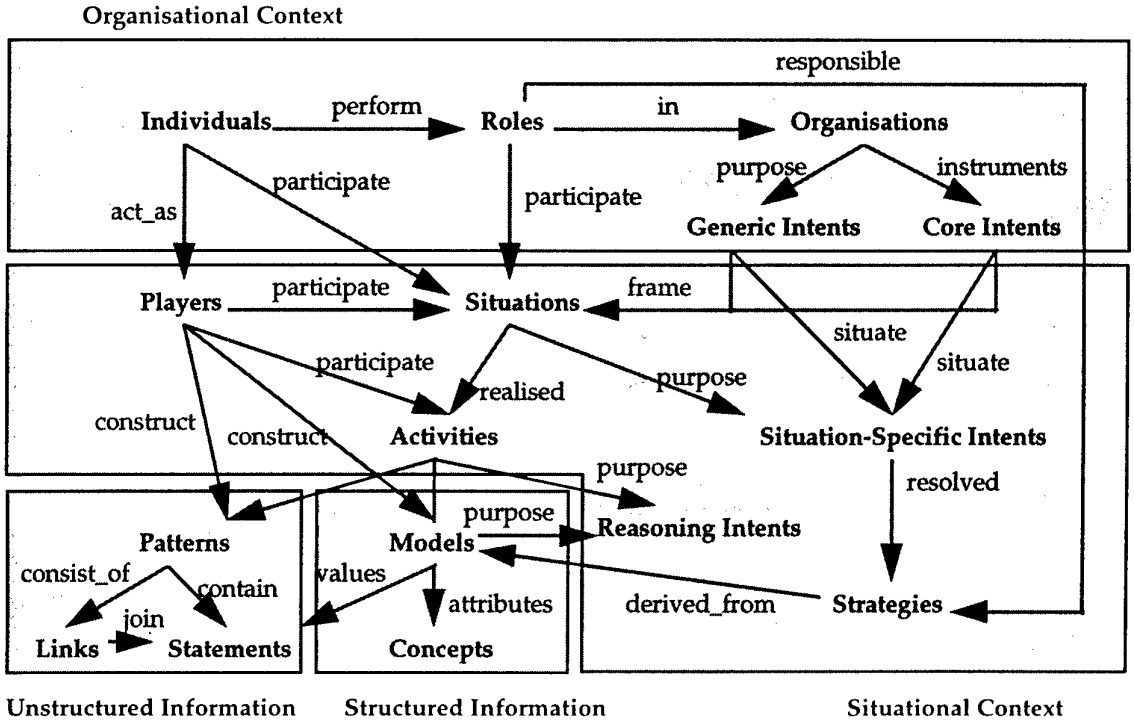

Figure 4.4 Linkages between the framing elements

These elements are organised into the following four categories: elements for unstructured information, elements for structured information, elements for organisational context, and elements for situational context.

4.3.1 Unstructured Information

Producing structured information about a situation is one of the outputs of the framing process. In order to produce structured information, people in social worlds often communicate using unstructured information which is increasingly structured as the group's understanding of the situation increases. One way of communicating unstructured information is by using a whiteboard. On a whiteboard, people can write text statements, link them together diagrammatically, change the text statements, and then reorganise these linkages as a shared understanding develops. The whiteboard metaphor forms the basis for using hypertext knowledge representation techniques for unstructured information. There are three elements: statements, links and patterns.

4.3.1.1 Statements

Statements represent the text statements created by people on a whiteboard. These statements are either linked together to form patterns, or are values of concept descriptions in models. Statements are represented as frames. The statement frame contains the following slots:

- textString - the text statement
- context - the pattern or model in which the text statement is used

4.3.1.2 Links

Links represent the hypertext links between statements in a pattern. Links are represented as frames with the following slots:

- textString1 - the first statement being linked
- textString2 - the second statement being linked
- pattern - the pattern in which the link is created and used

4.3.1.3 Patterns

Patterns implement the whiteboard metaphor and include all the statements and links described on the "whiteboard". Patterns are represented as frames with the following slots:

- name - the name of the pattern
- statements - a list of all the statements constructed and used in the pattern
- links - a list of all the links constructed and used in the pattern
- activity - the activity in which the pattern is constructed and used

The activity provides the mechanism for accessing situational information about the situation in which the pattern is constructed and used, and the player who constructed the pattern. The player provides the mechanism for accessing organisational information

4.3.2 Structured Information

Constructing framing knowledge representations for a situation requires people to name and describe the relevant concepts in the situation and then reason about these concepts in the form of models. Naming, and using descriptions of concepts, forms the basis of expanding the pool of knowledge representations.

4.3.2.1 Concepts

Concepts are conceived and named by people. They are abstract cognitive representations of reality, or a cognitive invention, for example, a plan. Concepts are represented as concept description networks consisting of a Concept object and a Concept Description object.

Concept object

- name - name of the concept
- conceptDescription - list of all the descriptions for the concept

Concept Description object

- name - name of the concept
- attributes
- context - the model description in which the concept description is created and used

4.3.2.2 Models

Models are simplified descriptions of the real-world environment created by people to enable them to reason about a situation. Models are used to categorise data from the real-world environment using concept descriptions that identify the basic-level categories. Models also form relationships between concept descriptions creating framing concept hierarchies. Models are represented as model description networks.

Model object

- name - name of the model
- modelDescriptions - a list of all the descriptions for the model

Model Description object

- name - name of the model
- attributes - a list of the attributes for the model, each attribute being a concept description
- conceptMeanings - is used to define framing concept hierarchies whose root node is the concept description for the attribute. Each entry is a list whose first member is the "root node", and the following concept descriptions are the next level in the concept hierarchy. Each of these concept descriptions is then represented as a list and so on
- contexts - a list of the activities and intents in which the model is used

4.3.3 Organisational Context

The theory of framing presented in Chapter 2 assumes that the framing process occurs in an organisational context. The organisational context assists in deciding who should participate in the framing process, what skills are required, how framing occurred in similar situations, and who was involved. The organisational context thus provides a mechanism for navigating the corporate memory. The elements of organisational context used to support the framing process are: organisations, roles, individuals, generic intents and core intents.

4.3.3.1 Organisation

People perform their work in organisations by performing a role for a purpose, or intent. Organisations are represented as frames containing the slots:

- name - the name of the organisation
- genericIntents - the list of the generic intents, or purpose of the organisation
- coreIntents - the list of the core intents, or capabilities of the organisation
- roles - the list of roles in the organisation
- individuals - the list of individuals in the organisation

4.3.3.2 Role

Roles are responsible for achieving intents in an organisation by implementing strategies as actions. Roles are represented as frames containing the slots:

- name - the name of the role
- organisation - the organisation for which the role works
- intents - a conceptual view of the work performed by the role (both routine work and situated work)
- strategies - a descriptive view of the work performed by the role (both routine work and situated work)
- individuals - the individuals who have performed and are currently performing the role
- situations - the situations in which the role has participated and is currently participating

4.3.3.3 Individuals

Individuals are the people in the organisation. They are responsible for framing and solving situations. Individuals are represented as frames containing the slots:

- name - the name of the person
- roles - the roles the person has performed, and is currently performing
- situations - the situations in which the person has participated and is currently participating

4.3.3.4 Generic Intents

Generic intents represent the purpose of the organisation and are used as generative metaphors for recognising and describing situations. Generic intents are represented as intent description networks consisting of an Intent object and an Intent Description object.

Intent object

- name - name of the intent
- intentDescriptions - a list of all the descriptions for the intent

Intent Description object

- name - the name of the intent
- attributes - the model descriptions that describe the intent and are used for applying an intent as a generative metaphor
- roleResponsible - the role in the organisation responsible for ensuring the intent is framed and resolved
- situations - the situations in which the intent has been used, and is currently being used
- organisation - the organisation which framed the intent

4.3.3.5 Core Intents

Core intents represent the capabilities of the organisation and are used as generative metaphors for recognising and describing situations. Core intents are represented as intent description networks consisting of an Intent object and an Intent Description object.

Intent object

- name - name of the intent
- intentDescriptions - a list of all the descriptions for the intent

Intent Description object

- name - the name of the intent
- attributes - the model descriptions that describe the intent and are used for applying an intent as a generative metaphor
- roleResponsible - the role in the organisation responsible for ensuring the intent is framed and resolved

- situations - the situations in which the intent has been used, and is currently being used
- organisation - the organisation which framed the intent

4.3.4 Situational Context

The framing process requires people to identify a situation in the real-world environment using a framing intent, then socially reason about the situation by constructing and using various representations. The elements for supporting people reasoning about a situation are: situation, activity, player, reasoning intent, situation specific intent, strategy.

4.3.4.1 Situation

Situations are conceptual constructs. They are the state of affairs perceived by people as they interpret the real-world environment. Situations are represented as frames containing the slots:

- name - the name of the situation
- framing intent - the generic intent or core intent used to recognise the situation and describe the situation after being applied as a generative metaphor
- activities - the activities performed in the situation, and the social world for the situation is the players participating in all the activities for the situation
- situation specific intent - situates the framing intent

The framing intent is a mechanism for accessing the organisational contextual information. The activity is the mechanism for getting to the models, patterns, reasoning intents, individuals and roles.

4.3.4.2 Activity

An activity is the work performed by people as part of the framing process. This work can either be performed by a group or by individuals. Activities are represented as frames with slots:

- name - the name of the activity

- situation - the situation in which the activity is performed
- players - the set of players for the activity forms the social world, the players provide the mechanism for accessing the models and patterns for individuals, shared information and background information
- status - the status of the activity is either ongoing or closed
- reasoning_intent - describes the purpose of the activity

4.3.4.3 Player

A player represents an individual participating in an activity, background information for the activity, or shared information constructed during the activity. A player relates the individual's and role's concepts, models, intents and patterns to an activity. A player is represented as a frame containing the slots:

- individual - the person participating in the activity
- activity - the activity the person is participating in
- status - states whether the individual is currently participating in the activity
- concepts - a list of the concepts constructed and used in the activity by the player
- models - a list of the models constructed and used in the activity by the player
- intents - a list of the intents constructed and used in the activity by the player
- patterns - a list of the patterns constructed and used in the activity by the player

4.3.4.4 Reasoning Intent

Reasoning intents are the purpose for performing an activity or constructing a model. Reasoning intents can be chained together to form a line of reasoning from the framing intent for the situation through to the situation-specific intent. Reasoning intents are represented as intent description networks consisting of an Intent object and an Intent Description object.

Intent object

- name - name of the intent

- intentDescriptions - a list of all the descriptions for the intent

Intent Description object

- name - the name of the intent
- attributes - the model descriptions that describe the intent
- roleResponsible - the role in the organisation responsible for ensuring the intent is framed and resolved
- context - the activity or model in which the intent is used
- organisation - the organisation which framed the intent
- strategies - a description of who needs to do what in reasoning about a situation

4.3.4.5 Situation Specific Intent

Situation specific intents describe the purpose of an organisation in a situation. Situation specific intents are represented as intent description networks consisting of an Intent object and an Intent Description object.

Intent object

- name - name of the intent
- intentDescriptions - a list of all the descriptions for the intent

Intent Description object

- name - the name of the intent
- attributes - the model descriptions that describe the intent
- strategies - the strategies for resolving the situation
- roleResponsible - the role in the organisation responsible for ensuring the intent is framed and resolved
- situations - the situations in which the intent has been used, and is currently being used
- organisation - the organisation which framed the intent

- end-state - a description for recognising the end of the situation

4.3.4.6 Strategy

Strategies represent the manifestation of the situation-specific intent for a situation, or a reasoning intent for an activity. They describe how the situation will be resolved or who needs to do what in reasoning about an activity. Strategies are represented as frames containing the slots:

- who - the individual or role responsible for ensuring the strategy is performed
- when - the datetime the strategy must be performed by
- what - what the strategy must do
- context - the situation-specific intent or reasoning intent which defines the purpose for performing the strategy

4.4 Using the Sixteen Framing Elements

This section works through a scenario to demonstrate how the sixteen framing elements are used to support framing and the construction of framing knowledge representations. The first part of the scenario shows how the framing elements are used to frame a situation and construct a framing knowledge representation from an individual's perspective. The second part of the scenario describes how different descriptions emerge for a concept in a social world and how a shared description for the situation is constructed.

4.4.1 Creating Situated Representations During Framing

This section reuses the humanitarian disaster relief scenario described in Chapter 3 to illustrate how the sixteen framing elements are used to create situated representations and how the pool of knowledge expands during the framing process as situated representations are constructed.

A starting point is to define the individuals performing roles in organisations. In this case, Bill Smith performs the role EAC in the Australian Defence Force.

Individual

- name: Bill Smith

- roles: EAC

- situations: <>

Role

- name: EAC

- organisation: Australian Defence Force

- intents: humanitarian disaster relief in the south-west Pacific

- strategies: <>

- individuals: Bill Smith

- situations: <>

Organisation

- name: Australian Defence Force

- genericIntents: humanitarian disaster relief in the south-west Pacific

- coreIntents: Transportation

- roles: EAC

- individuals: Bill Smith

EAC is responsible for the generic intent "humanitarian disaster relief in the south-west Pacific".

GenericIntent

- name: humanitarian disaster relief in the south-west Pacific

- intentDescriptions: humanitarian disaster relief in the south-west Pacific1

Humanitarian disaster relief in the south-west Pacific1

- attributes: contingency plan1

- roleResponsible: EAC

- situations: <>

- organisation: Australian Defence Force

The contingency plan for this generic intent is represented as a model.

Model

- name: contingency plan

- modelDescriptions: contingency plan1

Model Description

- name: contingency plan1

- attributes: Communications1, Transport1, General Stores1, Constraints1

- conceptMeanings: Communications1, <>

Transport1, Transport Aircraft1, Sea Transport1, Helicopters1

Transport Aircraft1, C130-1

C130-1, <>

Sea Transport1, <>

Helicopters1, <>

General Stores1, <>

Constraints1, <>

- context: humanitarian disaster relief in the south-west Pacific

Concept

- name: C130

- conceptDescriptions: C130-1

C130-1

- attributes: maximum load, maximum range, cruising speed

- context: Contingency plan1

Bill Smith receives an AAP press release that states that volcanic eruptions have occurred in Rabaul. He interprets this as a relevant event to the organisation and uses the generic intent "humanitarian disaster relief in the south-west Pacific" to frame the situation. This generic intent has a description which is used as the basis for constructing a framing knowledge representation, selecting the transport concept hierarchy as being relevant in this situation. The new elements added to the pool of knowledge are a new situation, activity, player, model and model description.

Situation

- name: humanitarian disaster relief in Rabaul

- framingIntent: humanitarian disaster relief in the south-west Pacific

- activities: disaster meeting

- situation-specific Intent:

- strategies:

Activity

- name: disaster meeting

- situation: humanitarian disaster relief in Rabaul

- players: <shared>

- status: ongoing

- intents: <>

Player

- name: <shared>

- individual: <>

- activity: disaster meeting

- status: currently participating

- concepts:

- models: transport1

- intents: <>

- patterns: <>

Model

- name: transport

- modelDescriptions: transport1

Model Description

- name: transport1

- attributes: Transport Aircraft1, Sea Transport1, Helicopters1

- conceptMeanings: Transport Aircraft1, C130-1

Sea Transport1, <>

Helicopters1, <>

- context: humanitarian disaster relief in Rabaul

The framing intent is situated by defining the purpose of the organisation as "provide humanitarian disaster relief to the people of Rabaul" and constructing a situation-specific intent.

Situation-Specific Intent

- name: provide humanitarian disaster relief to the people of Rabaul

- intentDescriptions: <>

Whilst reasoning about the situation, Bill Smith is notified that a hovercraft may be available in the Rabaul area. Hovercraft are a new concept for the defence force and are included in the reasoning by naming and describing the concept, although nothing is currently known about the capabilities of the hovercraft and no attributes are defined, then updating the model to include the concept. The new elements added to the pool of knowledge are a new concept and concept description, and the model description is updated with the new concept description.

Concept

- name: Hovercraft

- conceptDescriptions: Hovercraft1

Concept Description

- name: Hovercraft1

- attributes: <>

- context: Transport1

Model Description

- name: transport1

- attributes: Transport Aircraft1, Sea Transport1, Helicopters1, Hovercraft1

- conceptMeanings: Transport Aircraft1, C130-1

Sea Transport1, <>

Helicopters1, <>

Hovercraft1, <>

- context: humanitarian disaster relief in Rabaul

This scenario demonstrates how the framing elements support construction of a framing knowledge representation during framing. A description of the generic intent is used as the basis for constructing the situation, an activity for reasoning, and a model with selected concept descriptions from the generic intent description. A new concept is defined and added to the model, updating the models framing concept hierarchies. On the completion of this scenario, a reflective activity would investigate whether to treat this new concept description and framing concept hierarchy as a unique situation, or whether they should be integrated into the description of the generic intent.

4.4.2 Reasoning about the same concept with different descriptions

The concept of "weapon system" has quite different descriptions in the Navy and Air Force. In the Navy, a weapon system is the whole ship and it's total fighting capability. A weapon system in the Navy can be represented as a concept description.

Concept

- name: weapon system

- conceptDescriptions: weapon system1, weapon system2

Concept Description

- name: weapon system1

- attributes: ship's name, ship type, number of crew, missiles, guns, radars, sonars

- context: Navy

In the Air Force, a weapon system is a part, something that is bolted onto an aircraft providing the aircraft with a new capability. A weapon system in the Air Force can be described in multiple ways. A weapon system in the Air Force can be represented as a concept hierarchy.

Concept Description

- name: weapon system2

- attributes: weight, warload, range, command and control system

- context: Air Force, aircraft1

Model

- name: Aircraft

- modelDescriptions: Aircraft1

Model Description

- name: Aircraft1

- attributes: weapon system2

- conceptMeaningList: weapon system2, missiles1, guns1, radars1

- context: Air Force

Consider the situation where the hovercraft concept defined in Section 4.4.1 is to be operated as a joint capability between the Navy and the Air Force. That is, both the Navy and Air Force will have personnel operating the hovercraft. What happens when a study is conducted by social world examining the cost/benefits trade-off of acquiring a missile air defence system? The Air Force personnel will start discussing the missile air defence system as a weapon system and how it integrates with the hovercraft. This will confuse the Navy personnel who will view the whole hovercraft as the weapon system. This dilemma can be resolved by negotiating the meaning of a weapon system in relation to the hovercraft. Either one of the definitions of weapon systems is accepted as being the "correct" definition for hovercraft, or a new concept name is introduced that enables all the personnel to map their definitions of weapon system and facilitates social reasoning about the hovercraft. This new concept name then becomes an important part of the description of a hovercraft that enables other people to understand and reason about hovercraft. The real underlying issue here is whether operating a hovercraft is subsumed by an existing social world, or whether a new social world emerges to operate hovercraft.

4.5 Discussion

One outcome from supporting the theory of framing with descriptive networks is that there are at least three types of concept hierarchies in any computational system supporting the framing process. The three types of concept hierarchies are descriptive network concept hierarchies, framing concept hierarchies, and computational concept hierarchies.

Descriptive network concept hierarchies are described in Section 4.2.3. These concept hierarchies group abstractions by the type of framing element they represent, then group all the situated descriptions for these abstractions.

Framing concept hierarchies are described in Section 4.2.3.2. These concept hierarchies are the result of people negotiating the set of basic-level concept descriptions for a situation and categorising them in some meaningful way.

Computational concept hierarchies result from the implementation of a knowledge representation into code. Implementing a knowledge representation in code requires computationally efficient ways of reasoning about these objects. Gamma et al (1995) have shown that computationally efficient concept hierarchies often bear no relation to the framing concept hierarchies and descriptive network concept hierarchies that people use for reasoning.

4.6 Summary

Sixteen framing elements have been described that enable people to construct framing knowledge representations during the framing process. These framing elements cover unstructured information, structured information, organisational context and situational context. The key knowledge representation technique underlying these framing elements is the notion of descriptive networks. Abstractions in descriptive networks have many descriptions and these descriptions provide the richness for framing situations. Descriptive networks support the notion that multiple descriptions of an abstraction may co-exist in a single context. These descriptive networks are different from knowledge representations used in knowledge-based systems because they do not represent the knowledge used for reasoning in the system. Instead, they are a mechanism that people use to describe and communicate their understanding of the situation, and to coordinate and align their activities in the situation.

5. FRAMER: An Implementation

> *Understanding may require using multiple representations at once* --Marvin Minsky

This chapter describes a system called FRAMER. FRAMER supports people framing situations by enabling them to construct and negotiate meaning about framing knowledge representations by direct manipulation. FRAMER is implemented in Smalltalk and is in a continual state of evolution and development. This chapter starts by describing an architecture for FRAMER and then presents an overview of the current implementation of FRAMER. The current implementation of FRAMER is tailored to support the requirements of the case study described in Chapter 6. The following sections then discuss the object representation and user interface for supporting framing.

A key feature of FRAMER's implementation is the ability to define new Smalltalk classes dynamically enabling the use of descriptive networks in constructing situated representations. A pragmatic approach to demonstrating the utility of descriptive networks in FRAMER has been taken by only representing the six framing elements that represent intents, models and concepts as descriptive networks. This restriction simplified prototyping and testing the descriptive networks knowledge representation technique whilst still providing sufficient richness to support the case study described in Chapter Six. The remaining ten framing elements are represented as frames. The frame representation results in the inability to define multiple descriptions of abstractions defined using these framing elements. The frame representation makes it difficult to redesign organisation structures and activity systems, and it is difficult to adapt and reuse descriptions across situations.

An overview of the user interface is described, then individual screens are presented in the following categories: organisational context, situational context, unstructured information, and structured information. Appendix A describes FRAMER's installation requirements and naming conventions.

5.1 Architecture

Figure 5.1 shows the main elements of the architecture for supporting people framing situations. The aim of this architecture is to enable people to construct framing knowledge representations that describes their individual mental models and shared understanding of the situation. The architecture consists of computer hardware, operating systems, networks, persistent object storage, distributed objects, framing elements, framing knowledge representations, user interface, individual mental models, and shared understandings. This architecture assumes that the computing hardware, operating systems and network environment is already implemented, enabling individuals to collaborate.

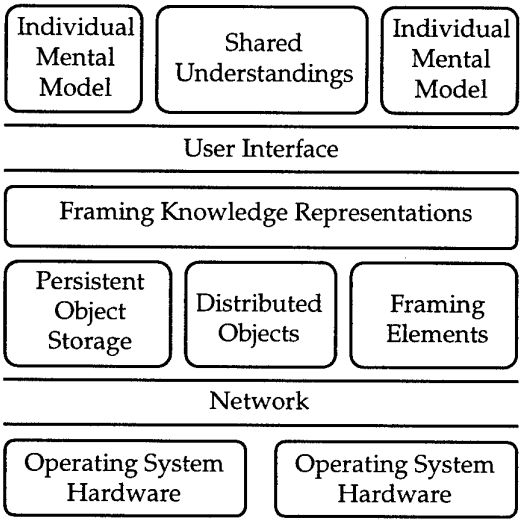

Figure 5.1 Architecture for supporting framing

On top of this networking environment, the architecture defines a persistent object storage, distributed objects and framing elements. The persistent object storage provides permanent storage for the situated representations that form part of the accumulating pool of knowledge. This storage may be in the form of databases, either centralised or distributed. Distributed objects provide the mechanism for moving objects around the system. Examples of distributed object mechanisms include DCE and CORBA. The framing elements are a language for constructing framing knowledge representations as described in Chapter 4.

The user interface enables people to construct, adapt and visualise the descriptions of their individual mental models and shared understandings as framing knowledge representations. In this manner, the user interface enables people to "directly access and manipulate" different parts of the accumulating pool of knowledge representations, reflecting the different organisational roles and experience of each individual.

5.2 Overview of FRAMER

Figure 5.2 shows the key features of the framing architecture that FRAMER implements. The focus of FRAMER is in demonstrating one method of supporting people constructing, adapting and visualising framing knowledge representations in an accumulating pool of knowledge representations.

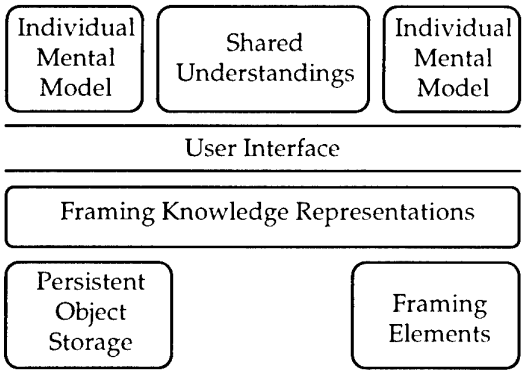

Figure 5.2 Overview of FRAMER's implementation

FRAMER is implemented in ParcPlace's VisualWorks 2.5 Smalltalk dialect as a stand-alone system. FRAMER supports multiple people by enabling them to login to the system and access different parts of the accumulating pool of knowledge representations. FRAMER's implementation can be viewed as three layers: user interface, object model and object storage. The framing elements are defined in the object model and are used to construct framing knowledge representations. The user interface enables people to directly manipulate these objects. Persistent object storage is provided by VisualWork's Binary Object Storage System (BOSS). BOSS handles reading and writing complex object structures to file. Further information about BOSS

can be found in Chapter 28 of the VisualWorks Cookbook. The rest of this chapter describes the implementation of the object model and user interface.

5.3 Object Representation

Chapter 4 identified sixteen framing elements for constructing framing knowledge representations in support of the framing process. These framing elements are represented as Smalltalk classes in FRAMER. Each Smalltalk class that represents a framing element contains attributes for linking instantiations of these classes together in the accumulating pool of knowledge representations. The Smalltalk object model is shown in Figure 5.3.

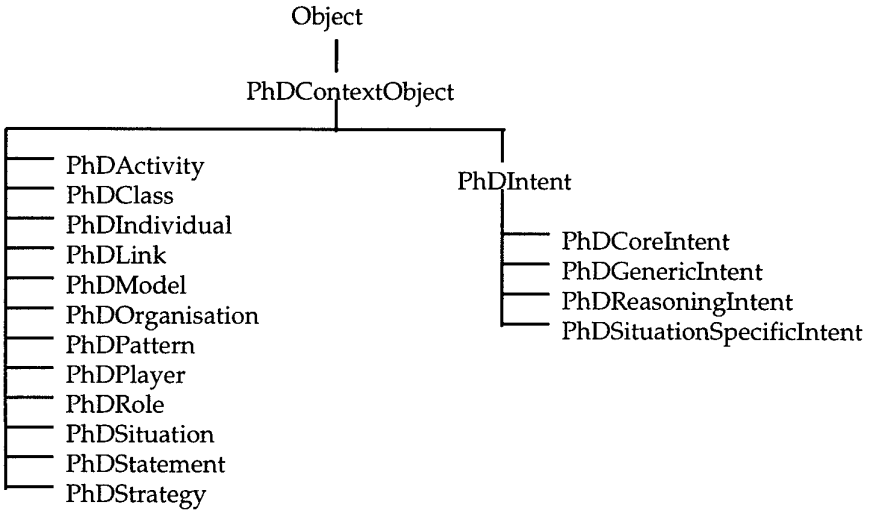

Figure 5.3 FRAMER's object model - implementing the framing elements

Constructing a framing knowledge representation involves instantiating these Smalltalk classes and selecting the relevant instances for the situation. The manner in which these Smalltalk classes are instantiated is dependent upon the knowledge representation technique used for the framing element that the Smalltalk class implements. A pragmatic approach to demonstrating the utility of descriptive networks in FRAMER has been taken by representing six framing elements, concepts (PhDClass), models (PhDModel), and intents (PhDCoreIntent, PhDGenericIntent, PhDReasoningIntent, and PhDSituationSpecificIntent) as descriptive networks. The other ten framing elements are represented as frames.

5.3.1 Instantiating Frames

Instantiating a Smalltalk class employing a frame knowledge representation requires creating a new instance of the class, and filling the slots or attributes for this instance.

5.3.2 Instantiating Descriptive Networks

Instantiating a Smalltalk class employing a descriptive network knowledge representation is more complex. A descriptive network requires the construction of new types of abstractions and multiple descriptions for each abstraction. Creating new abstractions and new descriptions is implemented in FRAMER by dynamically creating new Smalltalk classes at run-time by using the class construction features of the VisualWorks development environment.

Creating a new abstraction requires supplying a name for the abstraction, supplying the super class defines whether the class is a PhDModel, PhDClass, PhDCoreIntent, PhDGenericIntent, PhDReasoningIntent or PhDSituationSpecificIntent, the category defines where the Smalltalk class is stored in the development environment (either PhDClasses, PhDModels, PhDCoreIntents, PhDGenericIntents, PhDReasoningIntents or PhDSituationSpecificIntents), and a set of instances defines the instance variables. Creating a new description for an abstraction is similar to creating a new abstraction. The major differences are that the super class is the name of the abstraction, and that the category is either PhDMeanings, PhDModelTypeMeanings, or PhDIntentMeanings. The key code for creating new classes for abstractions and descriptions is shown below:

```
createClass: aClass super: aSuper category: aCategory instances: aSetOfInstances
 | aStream |
 aStream := String new writeStream.
 aStream nextPutAll: aSuper asSymbol.
 aStream nextPutAll: ' subclass: '.
 aStream nextPutAll: ('#', aClass) asSymbol.
```

```
aStream cr; tab; nextPutAll: 'instanceVariableNames: '''.
"Note: block statement should be enclosed in [ ] not ( )"
aSetOfInstances do: (:instVar | aStream nextPutAll: instVar.  aStream nextPutAll: '
'. ).
aStream nextPutAll: ''''.
aStream cr; tab; nextPutAll: 'classVariableNames: '''''.
aStream cr; tab; nextPutAll: 'poolDictionaries: '''''.
aStream cr; tab; nextPutAll: 'category: '''.
aStream nextPutAll: aCategory.
aStream nextPutAll: ''''.
aStream nextPutAll: '!!'.
aStream cr; cr; nextPutAll: '!!' , aClass asSymbol, ' methodsFor: "initialize-release"!!'.
aStream nextPutAll: #initialize.
aStream cr; cr; tab.
aStream nextPutAll: 'super initialize.'.
aStream nextPutAll: ' !! !!'.
aStream contents readStream fileIn.
```

This code produces a class definition and an initialize method that form part of the interpreted Smalltalk environment. Additional code produces new attributes and methods for using these methods in the dynamically created Smalltalk classes for abstractions and descriptions. An example class definition and method produced by this code are shown below:

```
PhDModel subclass #PhDtPredictiveModel
 instanceVariableNames: ''
 classVariableNames: ''
 poolDictionaries: ''
 category: 'PhDModels'!
!PhDtPredictiveModel methodsFor: 'initialize-release'!
intialize
 super initialize.! !
```

Instantiating a descriptive network requires creating a new instance of one of the abstraction's descriptions.

5.3.3 Constructing a Framing Knowledge Representation

Framing knowledge representations are constructed by people during the framing process. Constructing a computational framing knowledge representation requires a combination of: instantiating and selecting framing elements represented as frames; constructing descriptive networks; and selecting and instantiating the "appropriate" abstraction descriptions for the situation.

Figure 5.4 shows a very simplified situation representation. PhDIndividual employs a frame representation and has two instances representing people: "Bill" and "Paul". PhDSituation is also represented as a frame and has two instances: "Good weather" and "Bad weather". PhDModel employs a descriptive network knowledge representation. A new model abstraction "Weather Model" is constructed, dynamically creating the Smalltalk class "PhDtWeatherModel". This model abstraction has two model descriptions "Weather Model1" and "Weather Model2", which results in the dynamic creation of the Smalltalk classes "PhDwWeatherModel1" and "PhDwWeatherModel2". Two model instances have been created from the model description "Weather Model2", these being "Weather in America in July" and "Weather in Australia in January". For this example, Paul will be constructing the framing knowledge representation for the situation "Good Weather" which involves

selecting appropriate model descriptions and instances, in this case the model description "PhDwWeatherModel2" and the model instance "Weather in Australia in January".

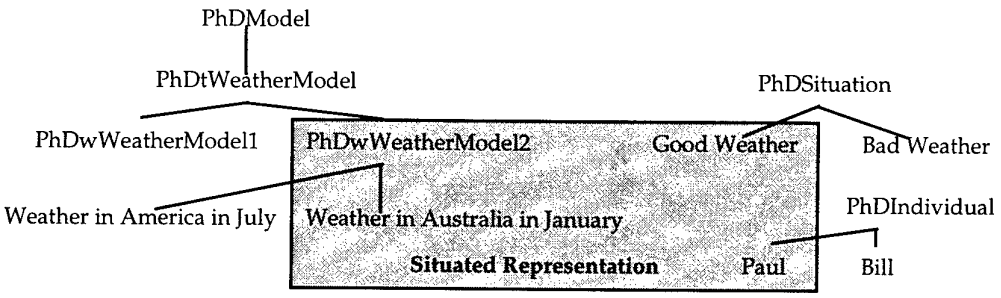

Figure 5.4 A simplified situated representation

This example illustrates how FRAMER supports both the computational representation of framing elements and the framing knowledge representations used by people that form the accumulating pool of knowledge representations.

5.4 User Interface

FRAMER's user interface supports people directly manipulating framing knowledge representations. It relies on the computational representation and interlinking of framing elements described in Chapter 4 as the basis for linking user interface screens together. These user interface screens enable people to navigate the accumulating pool of knowledge representations and construct framing knowledge representations. Figure 5.5 provides an overview of the relationship between user interface screens in FRAMER. PhDWorkspace is the startup screen for FRAMER. The following sections group these screens into the categories: organisational context, situational context, unstructured information and structured information.

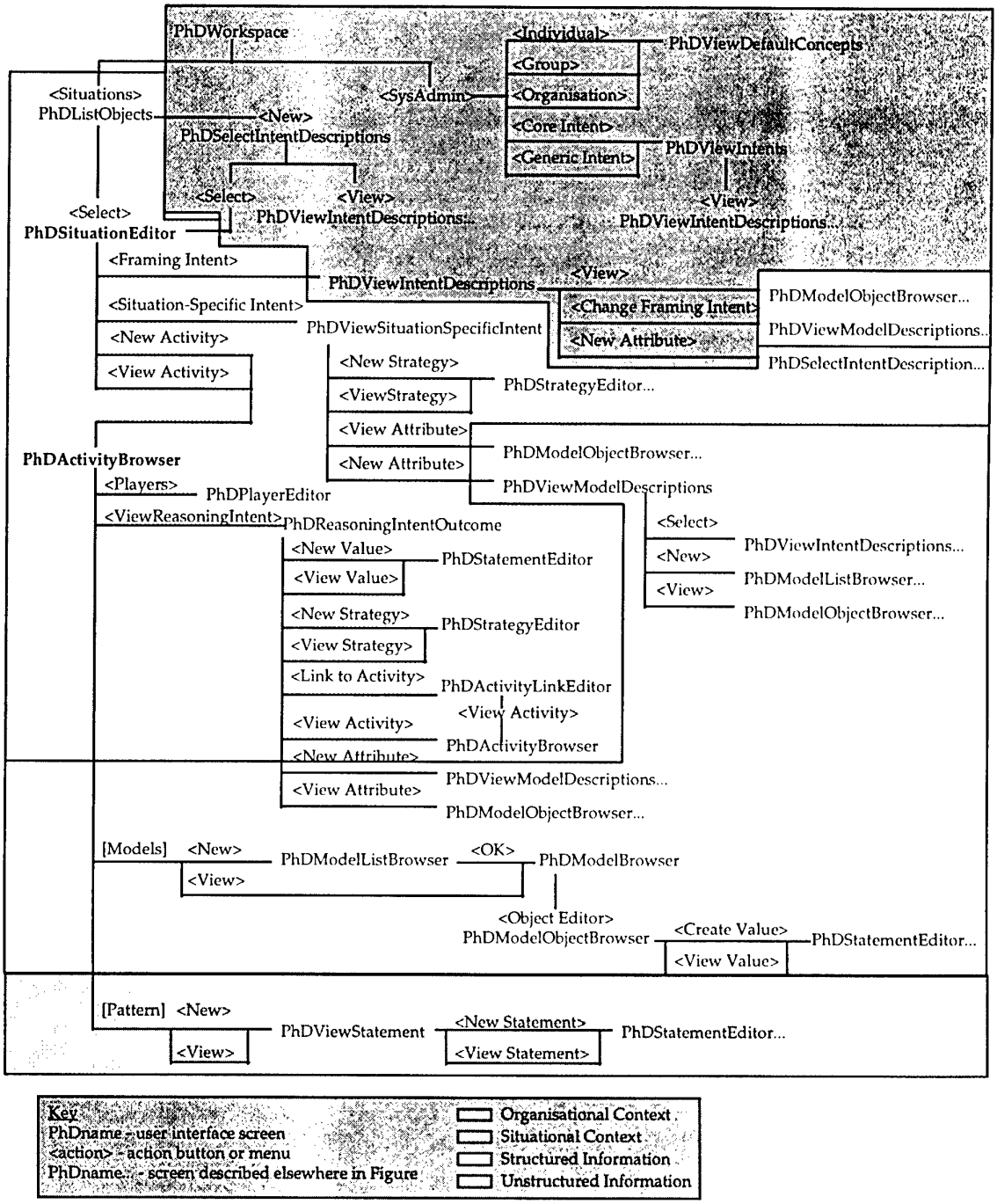

Figure 5.5 Relationship between user interface screens in FRAMER

The two key screens in FRAMER are PhDSituationEditor and PhDActivityBrowser. PhDSituationEditor has two purposes. It coordinates all the situational contextual information and is used to show the current state of reasoning and actions for a

situation from an organisational context. The PhDSituationEditor screen is then used to communicate this information to other communities of practice in the form of boundary objects. PhDSituationEditor is described in Section 5.6.3.

PhDActivityBrowser is used to reason within the situation. It supports people negotiating within a social world by relating the relevant situational context, unstructured information and structured information. PhDActivityBrowser is described in Section 5.6.5.

Each of the user interface screens are described in the following sections in terms of their ability to support people constructing and reasoning about framing knowledge representations. These sections describe the user interface screens' purpose, how they enable direct manipulation of the framing elements, contextual information for the user interface screen, and the actions that can be performed.

5.5 Organisational Context Module

The PhDWorkspace, PhDViewDefaultConcepts, PhDViewIntents and PhDViewIntentDescriptions user interface screens enable people to construct and reason about instances of organisational context framing elements. These elements are: PhDIndividual, PhDRole, PhDOrganisation, PhDCoreIntent, and PhDGenericIntent.

5.5.1 PhDWorkspace

PhDWorkspace is the startup screen for FRAMER and displays the individual logged on and the role(s) they are performing as shown in Figure 5.6. It has two purposes, firstly, initialising the FRAMER system, and secondly identifying and displaying the individual using the system. Initialising FRAMER involves retrieving the current instantiation of the object model from persistent storage, and constructing a PhDObjectContainer for handling the management, creation and destruction of these objects in memory. Logging on to FRAMER identifies the individual using the system, and enables FRAMER to establish the organisational context and roles being performed.

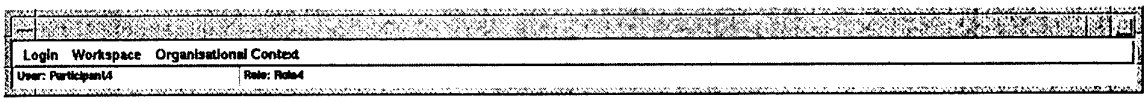

Figure 5.6 PhDWorkspace user interface screen

PhDWorkspace's menu structure enables the following actions to be performed:

- Login
  - Login - identifies the individual using the system, and thus the roles and organisational context
  - Logout - removes specific references to an individual
- Workspace
  - Situation - links to the PhDListObjects user interface screen which displays the situations in which the individual is currently participating, and enables people to reason about these situations
- Organisational Context
  - Individual, Role, Organisation - links to the PhDViewDefaultConcepts user interface and enables people to create new individuals, roles and organisations, and establish linkages between instances of these framing elements
  - Generic Intent, Core Intent - links to the PhDViewIntents user interface screen and enables people to create new types of generic intents and core intents, and new descriptions for these generic intents and core intents, new instances of these descriptions.

5.5.2 PhDViewDefaultConcepts

PhDViewDefaultConcepts enables people to construct, describe and link organisational contextual information as shown in Figure 5.7 The screen display enables people to view all instances, construct new instances, and delete instances of the PhDIndividual, PhDRole, and PhDOrganisation framing elements.

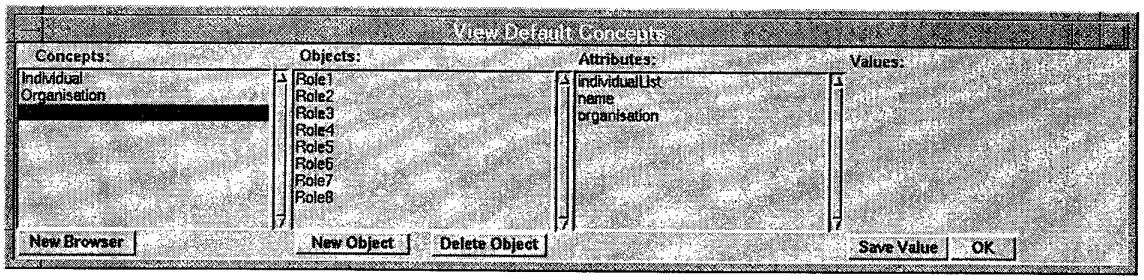

Figure 5.7 PhDViewDefaultConcepts user interface screen

PhDViewDefaultConcepts enables the following actions to be performed:

- New - depending upon the framing element selected, creates a new instance of either a PhDIndividual, PhDRole, or PhDOrganisation
- Delete - deletes the selected instance
- Save Value - saves the value of an attribute for an instance
- Drag-and-Drop - uses multiple PhDViewDefaultConcept and PhDViewIntents user interface screens to drag information from the instances list to the values list to enable defining contextual links between instances
- New Browser - opens a new PhDViewDefaultConcepts user interface screen
- OK - closes the PhDViewDefaultConcepts user interface screen

5.5.3 PhDViewIntents

PhDViewIntents enables people to construct and describe generic and core intents for an organisation as shown in Figure 5.8. The screen display enables people to construct new abstractions, and new descriptions of these abstractions, for PhDCoreIntent and PhDGenericIntent framing elements. These new abstractions and descriptions are constructed as new descriptive networks and result in the creation of new Smalltalk classes for the abstractions and descriptions.

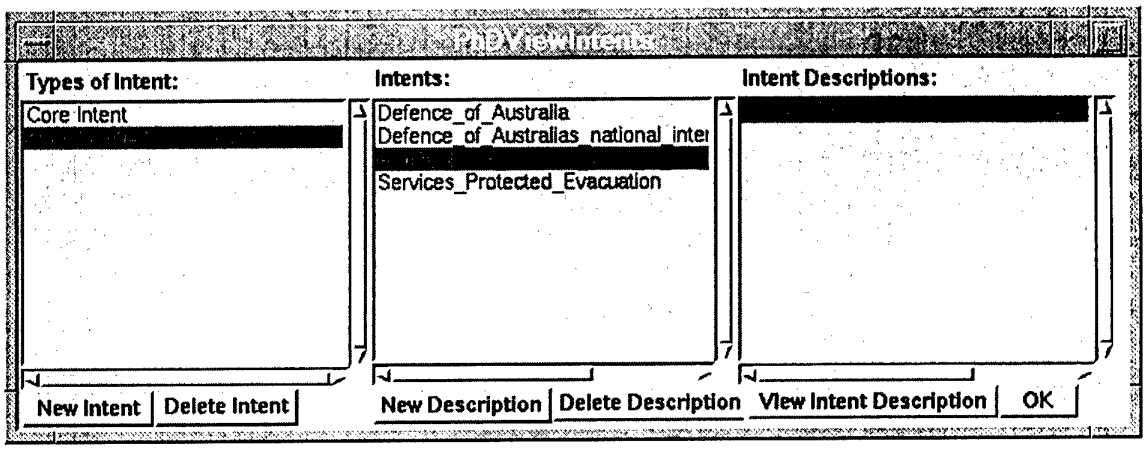

Figure 5.8 PhDViewIntents user interface screen

PhDViewIntents enables the following actions to be performed:

- New Intent - depending upon the framing element selected, creates a new abstraction of either a PhDCoreIntent or PhDGenericIntent. This abstraction forms the root node of a descriptive network.
- Delete Intent - deletes the selected intent and all its associated descriptions in the intent's descriptive network
- New Description - creates a new description for the selected intent, thus expanding the intent's descriptive network
- Delete Description - deletes the selected description from the selected intent's descriptive network
- View Intent Description - displays the selected intent description in a PhDViewIntentDescriptions user interface screen
- OK - closes the PhDViewIntents user interface screen

5.5.4 PhDViewIntentDescriptions

PhDViewIntentDescriptions enables people to define the detail for a description of a core or generic intent as shown in Figure 5.9. The screen display enables people to view the intent description as a set of model descriptions.

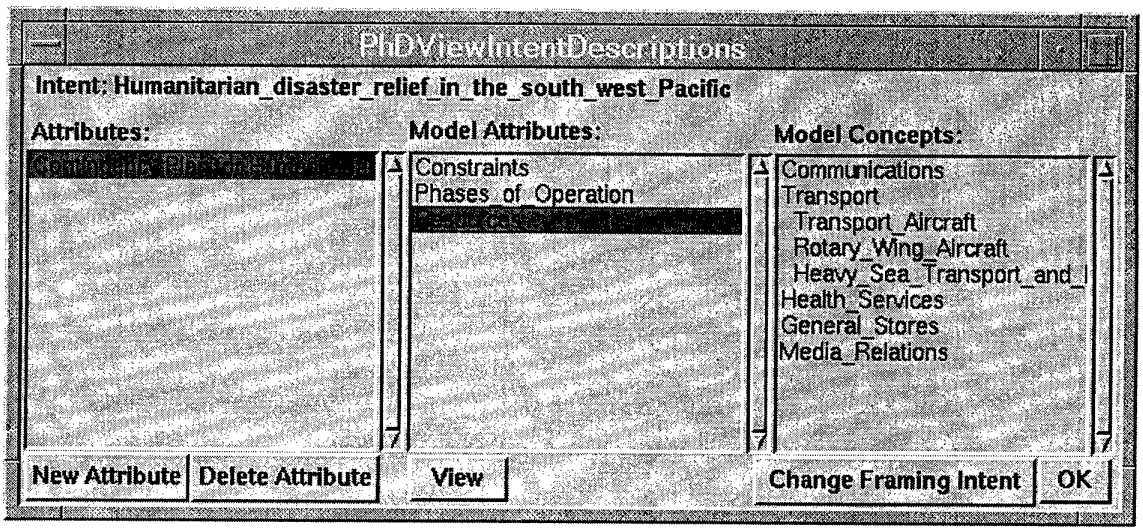

Figure 5.9 PhDViewIntentDescriptions user interface screen

Contextual information passed to PhDViewIntentDescriptions includes the intent description.

PhDViewIntentDescriptions enables the following actions to be performed:

- New Attribute - the attributes of an intent description are model description. New attribute enables people to select additional model descriptions to be attributes for the intent description by linking to the PhDViewModelDescription user interface screen
- Delete Attribute - deletes the selected model description from the intent description
- View - the selected attribute (model description) is displayed by linking to the PhDModelObjectBrowser user interface screen.
- Change Framing Intent - PhDViewIntentDescription enables people to view the framing intent for a situation. Change Framing Intent enables the users to select and alternative framing intent for a situation by linking to the PhDSelectIntentDescription user interface screen.

5.6 Situational Context Module

The PhDListObjects, PhDSelectIntentDescriptions, PhDSituationEditor, PhDActivityBrowser, PhDStrategyEditor, PhDReasoningIntentOutcome,

PhDPlayerEditor, and PhDActivityLinkEditor, user interface screens enable people to construct and reason about instances of situational context framing elements. The situational context framing elements are: PhDSituation, PhDActivity, PhDPlayer, PhDReasoningIntent, PhDSituationSpecificIntent, and PhDStrategy.

5.6.1 PhDListObjects

PhDListObjects enables people to construct and define the situation for framing as shown in Figure 5.10. The screen displays a list of all instances of the PhDSituation element for an individual. Constructing a situation involves creating a new PhDSituation instance.

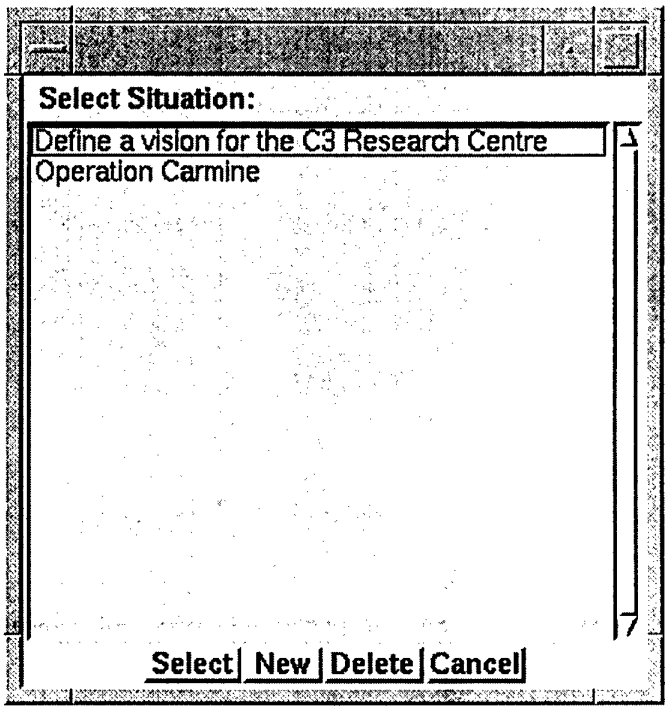

Figure 5.10 PhDListObjects user interface screen

Contextual information passed to PhDListObjects is the individual logged on to the system.

PhDListObjects enables the following actions to be performed:

- New - create a new situation by entering a name for the situation. A PhDSelectIntentDescription user interface screen is displayed enabling selection of a

framing intent for the situation, resulting in the new situation being displayed in the PhDSituationEditor user interface

- Select - the situation selected by the individual is displayed in the PhDSituationEditor user interface
- Delete - deletes an instance of PhDSituation for an individual
- OK - closes the PhDListObjects user interface screen

5.6.2 PhDSelectIntentDescriptions

PhDSelectIntentDescriptions enables people to select either a core intent or a framing intent for framing a situation as shown in Figure 5.11.

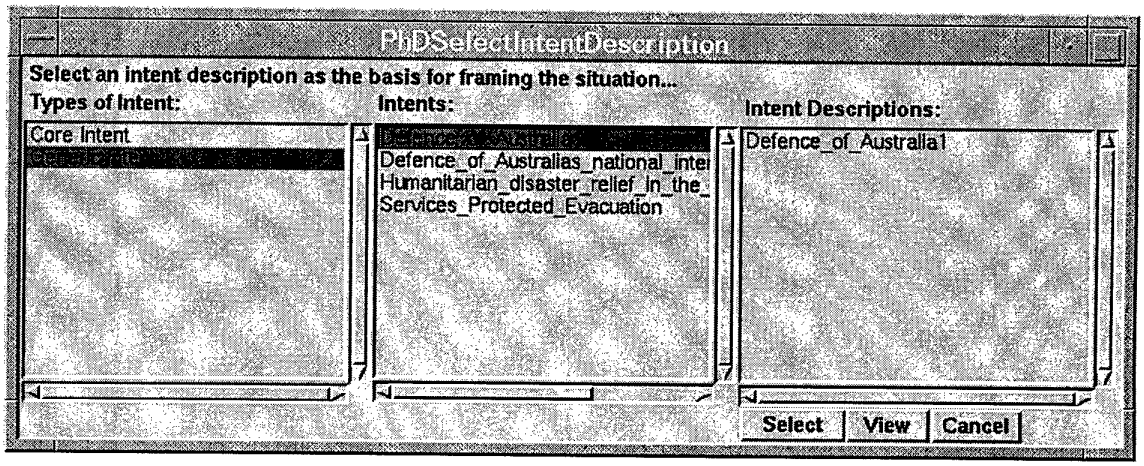

Figure 5.11 PhDSelectIntentDescriptions user interface screen

Contextual information passed to PhDSelectIntentDescriptions includes the situation, and the individual logged on to FRAMER.

PhDSelectIntentDescriptions enables the following actions to be performed:

- Select - the selected intent description is linked to the framingIntent slot for the situation. The situation is then displayed in the PhDSituationEditor user interface.
- View - displays the selected intent in a PhDViewIntentDescriptions user interface screen
- Cancel - closes the PhDSelectIntentDescriptions user interface screen

5.6.3 PhDSituationEditor

PhDSituationEditor enables people to construct and define activities for a situation, and reason about the situation's framing intent and situation-specific intent as shown in Figure 5.12. The screen displays a list of the instances of PhDActivity that are constructed for reasoning in the selected situation. Constructing an activity involves creating a new PhDActivity instance.

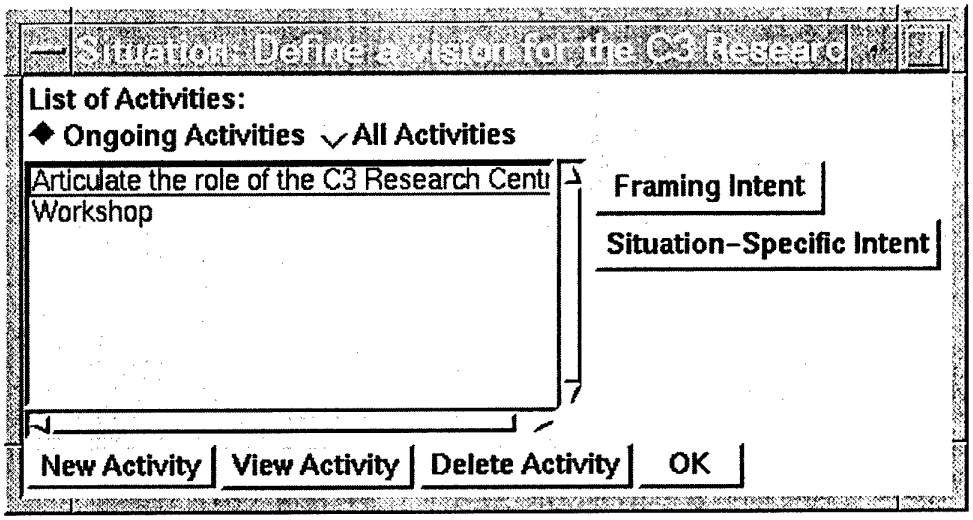

Figure 5.12 PhDSituationEditor user interface screen

Contextual information passed to PhDSituationEditor includes the individual logged on, and the selected situation.

PhDSituationEditor enables the following actions to be performed:

- New Activity - create a new activity by entering a name for the activity, creating a reasoning intent for the activity, and defining the individual logged on as a player in the situation. The new activity is displayed in the PhDActivityBrowser user interface
- View Activity - the selected activity is displayed in the PhDActivityBrowser user interface
- Delete Activity - deletes an instance of PhDActivity

- Framing Intent - the framing intent for the situation is displayed in a PhDViewIntentDescriptions user interface screen
- Situation-Specific Intent - if a situation-specific intent has not been created for the situation, a new abstraction and description are constructed for a PhDSituationSpecificIntent, creating a new descriptive network. An new instance is constructed from the intent description. The situation-specific intent instance is displayed in a PhDViewSituationSpecificIntent user interface screen.
- OK - closes the PhDSituationEditor

5.6.4 PhDViewSituationSpecificIntent

PhDViewSituationSpecificIntent is used to construct and define the concept and description for resolving the situation as shown in Figure 5.13. The screen displays the model descriptions that detail the situation, the end-state for the situation, and the strategies for achieving this end-state. As the situation evolves, the situation-specific intent is updated by either refining the model descriptions, end-state and strategies, or else by defining a new situation-specific intent description.

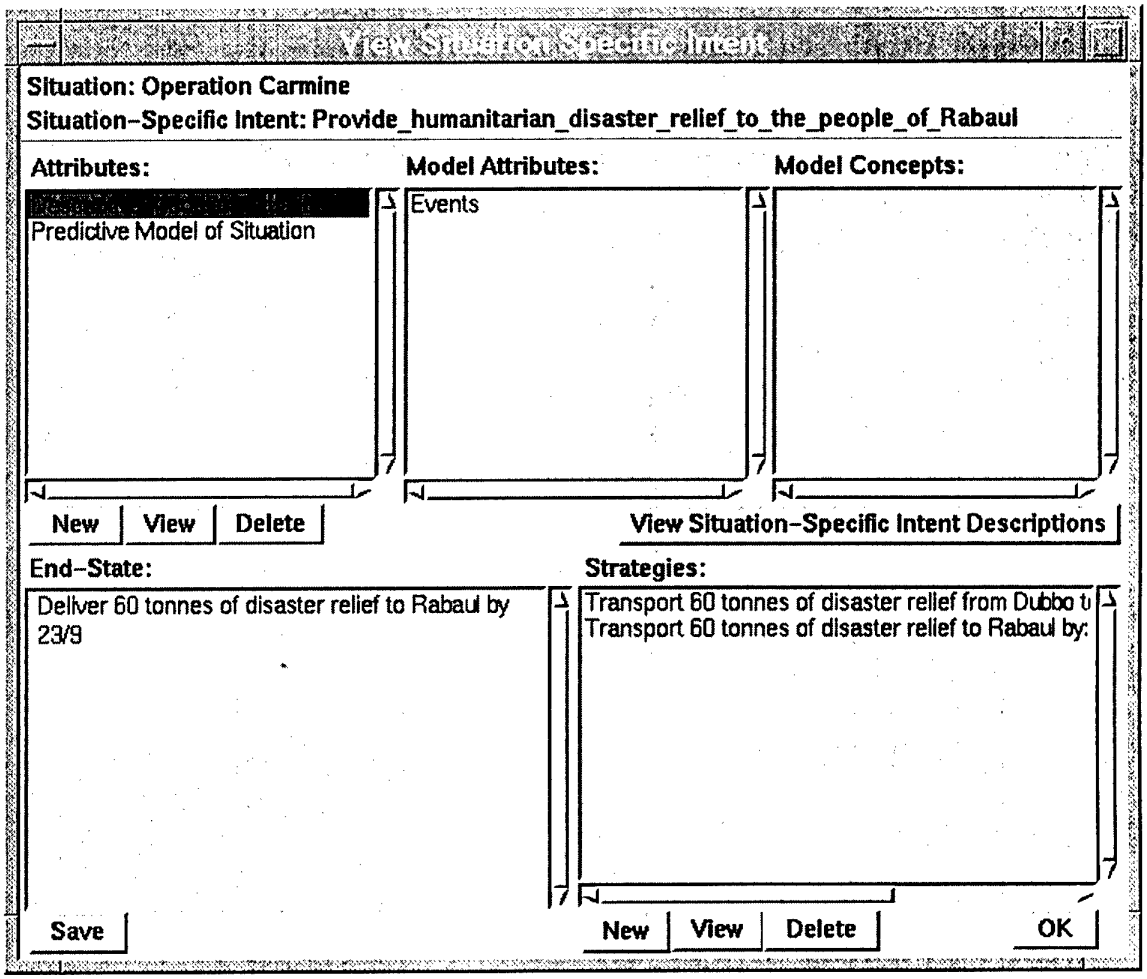

Figure 5.13 PhDViewSituationSpecificIntent user interface screen

Contextual information passed to PhDViewSituationSpecificIntent includes the situation.

PhDViewSituationSpecificIntent enables the following actions to be performed:

- New (attribute) - enables people to select model descriptions to be attributes for the situation-specific intent description by linking to the PhDViewModelDescription user interface screen.
- View (attribute) - the selected attribute (model description) is displayed by linking to the PhDModelObjectBrowser user interface screen.

- Delete (attribute) - deletes the selected model description from the situation-specific intent description
- View Situation-Specific Intent Descriptions - enables people to view the descriptive network for the situation-specific intent, construct new descriptions, and select the appropriate description for the situation.
- Save - save the end-state details
- New (strategy) - enables people to define new instances of PhDStrategy for resolving the situation by using the PhDStrategyEditor user interface screen to construct these strategies.
- View (strategy) - the selected strategy is displayed in the PhDStrategyEditor user interface.
- Delete (strategy) - deletes the selected instance of PhDStrategy.
- OK - closes the PhDViewSituationSpecificIntent

5.6.5 PhDActivityBrowser

PhDActivityBrowser is used to support people negotiating within a social world by defining the relevant situational contextual information, structured information and unstructured information for reasoning about an activity in a situation as shown in Figure 5.14. The screen displays a list of players participating in the social world for the activity, and the models and patterns used by these players. New patterns are constructed directly by creating a new PhDPattern instance. New models are constructed indirectly by linking to the PhDModelListBrowser user interface screen.

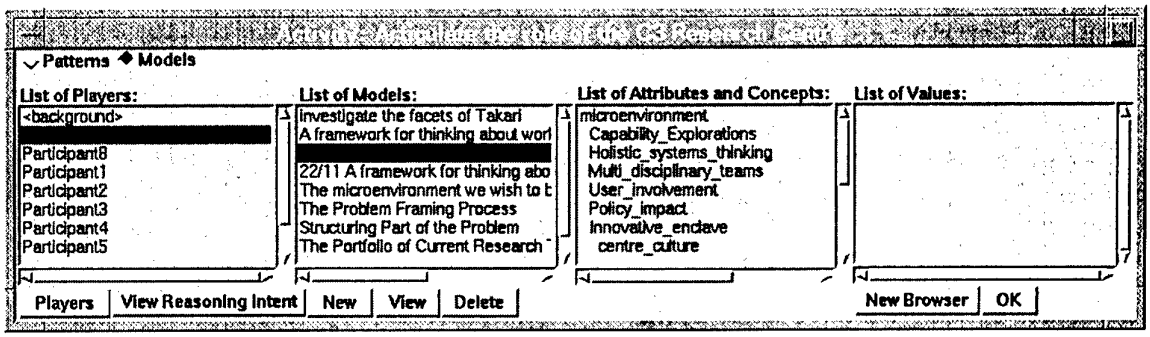

Figure 5.14 PhDActivityBrowser user interface screen

Contextual information passed to PhDActivityBrowser includes the individual logged on, and the selected activity.

PhDActivityBrowser enables the following actions to be performed:

- Players - links to the PhDPlayerEditor user interface screen that defines the players participating in the activity
- ViewReasoningIntent - links to the PhDReasoningIntentOutcome user interface screen that defines the strategies for other activities emanating from this activity.
- (pattern) New - creates a new pattern by entering a name for the pattern. The new pattern is displayed in the PhDViewStatements user interface screen
- (pattern) View - the pattern selected is displayed in the PhDViewStatements user interface screen
- (pattern) Delete - deletes an instance of PhDPattern
- (model) New - links to the PhDModelListBrowser that enables people to construct new types of models, new descriptions of models, and new instances from these descriptions.
- (model) View - the model selected is displayed in the PhDModelBrowser user interface screen
- (model) Delete - deletes an instance of a description of a model
- New Browser - opens a new PhDActivityBrowser user interface screen on the current activity

- OK - closes the PhDActivityBrowser

5.6.6 PhDPlayerEditor

PhDPlayerEditor enables people to define the membership of the social world participating in the activity as shown in Figure 5.15. The screen display enables people to select/deselect individuals. Selecting an individual creates an instance of the PhDPlayer framing element. To simplify the representation, background information and shared information are represented as players. Background information is contextual information from other activities that are relevant to the current activity. Shared information is the socially constructed patterns and models developed during reasoning about an activity.

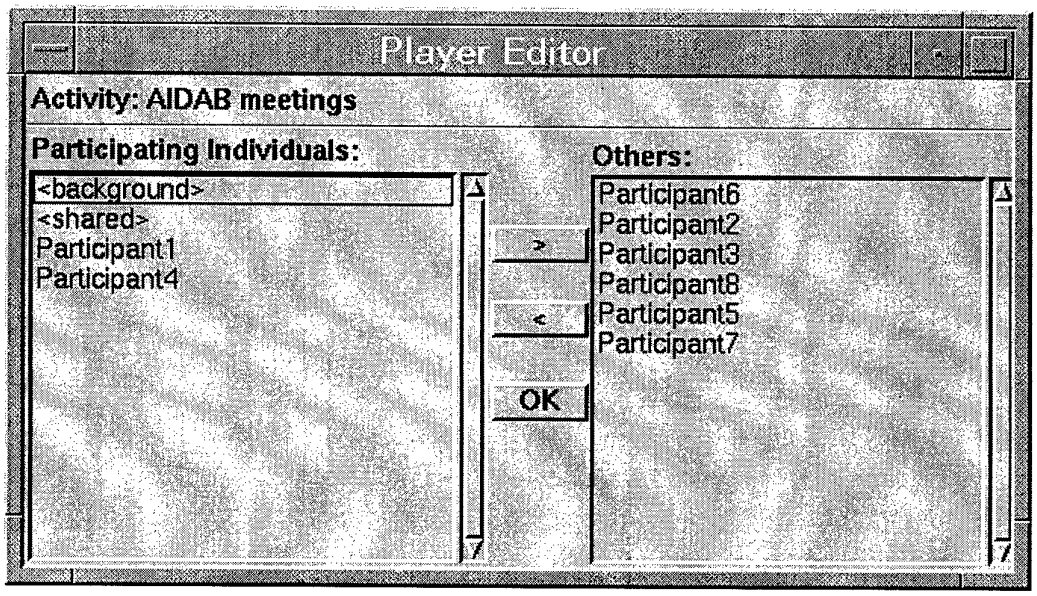

Figure 5.15 PhDPlayerEditor user interface screen

Contextual information passed to PhDPlayerEditor includes the activity.

PhDPlayerEditor enables the following actions to be performed:

- > - deselects an individual as a participant
- < - selects an individual as a participant, creating an instance of PhDPlayer for the activity

- OK - closes the PhDPlayerEditor user interface screen

5.6.7 PhDReasoningIntentOutcome

PhDReasoningIntentOutcome enables people to describe the reasoning intent for an activity as shown in Figure 5.16. The screen displays the model descriptions that detail the reasoning intent, the strategies for action resulting from reasoning about the activity, and these strategies are linked to further activities. As the activity evolves, the reasoning intent is updated by either refining the model descriptions, strategies and links to activities, or else defining a new reasoning intent description.

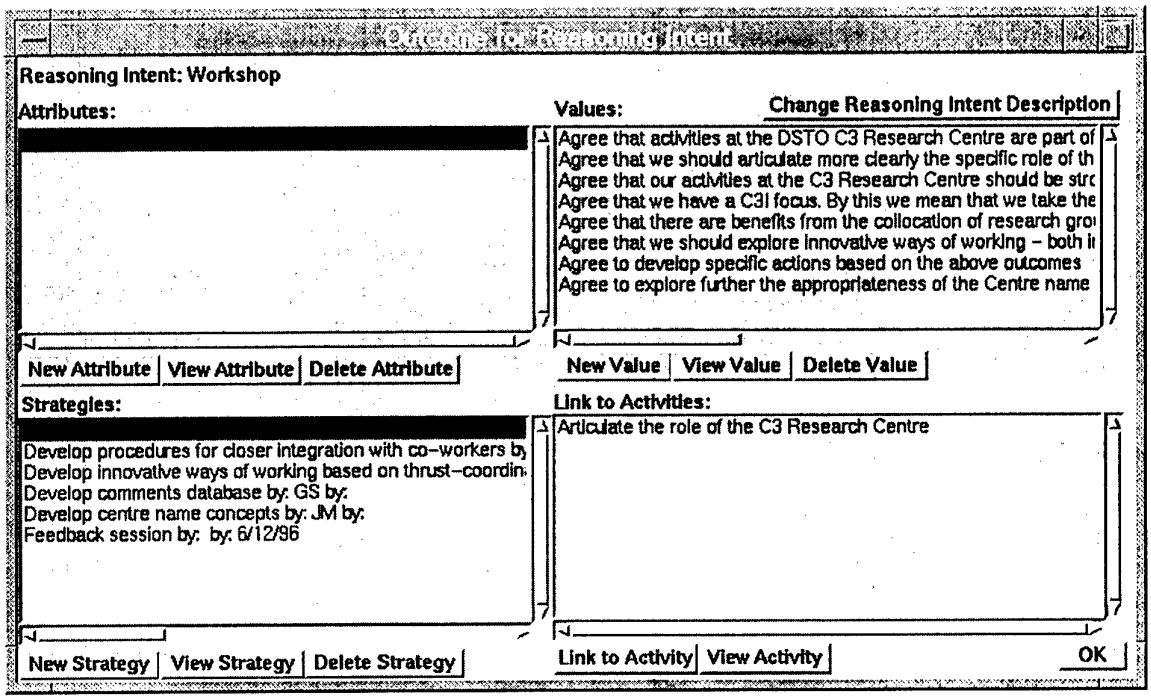

Figure 5.16 PhDReasoningIntentOutcome user interface screen

Contextual information passed to PhDReasoningIntentOutcome includes the activity and reasoning intent.

PhDReasoningIntentOutcome enables the following actions to be performed:

- New Attribute - enables people to select model descriptions to be attributes for the reasoning intent description by linking to the PhDViewModelDescription user interface screen

- View Attribute - the selected attribute (model description) is displayed by linking to the PhDModelObjectBrowser user interface screen
- Delete Attribute - deletes the selected model description from the reasoning intent description
- New Value - enables people to construct a new value for the selected model description by linking to the PhDStatementEditor user interface
- View Value - the selected value is displayed by linking to the PhDStatementEditor user interface screen
- Delete Value - deletes the selected value
- Change Reasoning Intent Description - enables people to view the descriptive network for the reasoning intent, construct new descriptions and select the appropriate description for the activity.
- New Strategy - enables people to define new instances of PhDStrategy for the activity by using the PhDStrategyEditor user interface screen to construct these strategies.
- View Strategy - the selected strategy is displayed in the PhDStrategyEditor user interface screen.
- Delete Strategy - deletes the selected instance of PhDStrategy
- Link to Activity - enables people to link strategies to activities by using the PhDActivityLinkEditor user interface screen
- ViewActivity - displays the selected activity in a PhDActivityBrowser user interface screen
- OK - closes the PhDViewReasoningIntentOutcome user interface screen

5.6.8 PhDStrategyEditor

PhDStrategyEditor enables people to describe a strategy as shown in Figure 5.17. People enter the what, when and who information that is used to describe an instance of PhDStrategy.

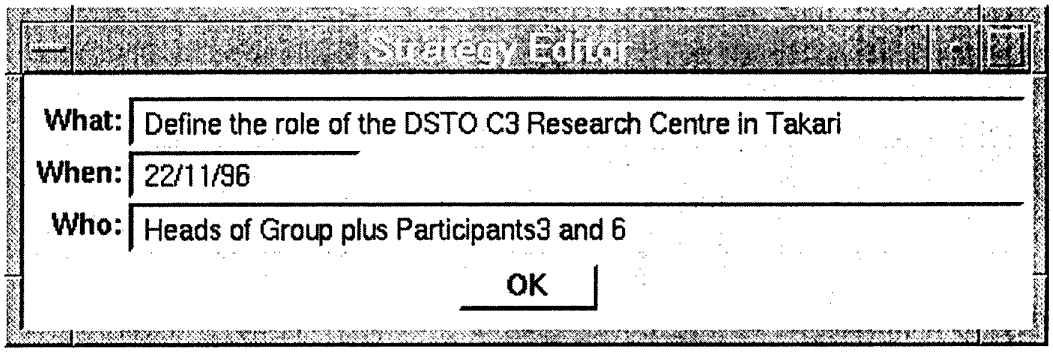

Figure 5.17 PhDStrategyEditor user interface screen

Contextual information passed to PhDStrategyEditor is the instance of the PhDStrategy.

PhDStrategyEditor enables the following actions to be performed:

- OK - closes the PhDStrategyEditor

5.6.9 PhDActivityLinkEditor

PhDActivityLinkEditor is used to link strategies to activities as shown in Figure 5.18.

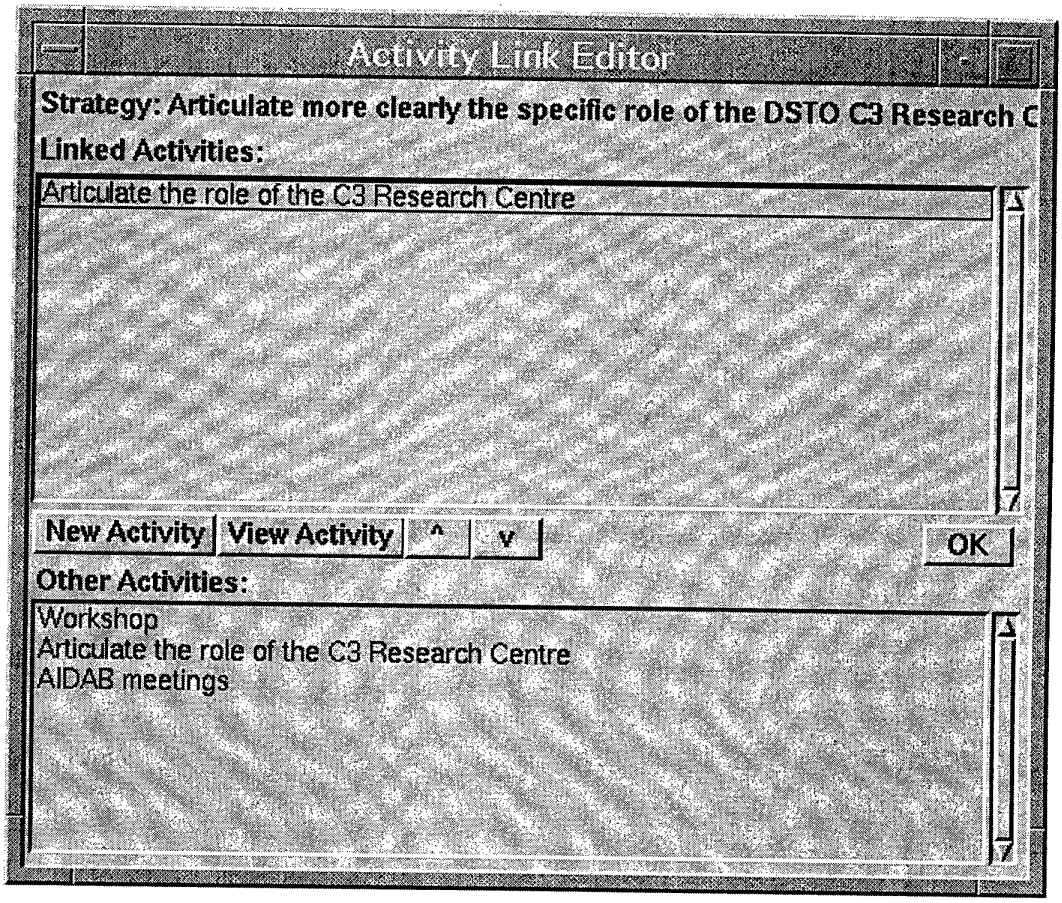

Figure 5.18 PhDActivityLinkEditor user interface screen

Contextual information passed to PhDActivityLinkEditor includes the strategy.

PhDActivityLinkEditor enables the following actions to be performed:

- New Activity - constructs a new instance of PhDActivity
- View Activity - displays the selected activity in a PhDActivityBrowser user interface screen
- ^ - links the selected activity to the strategy
- v - deletes the link between the selected activity and strategy
- OK - closes the PhDActivityLinkEditor user interface screen

5.7 Unstructured Information

The PhDStatementEditor and PhDViewStatements user interface screen enables people to construct and reason about instances of unstructured information framing elements. The unstructured information framing elements are: PhDStatement, PhDLink and PhDPattern.

5.7.1 PhDStatementEditor

PhDStatementEditor enables people to describe an instance of PhDStatement as shown in Figure 5.19. The screen displays a text description of the statement, and a keynote that is an abbreviated form of the text description that is used in graphically displaying patterns.

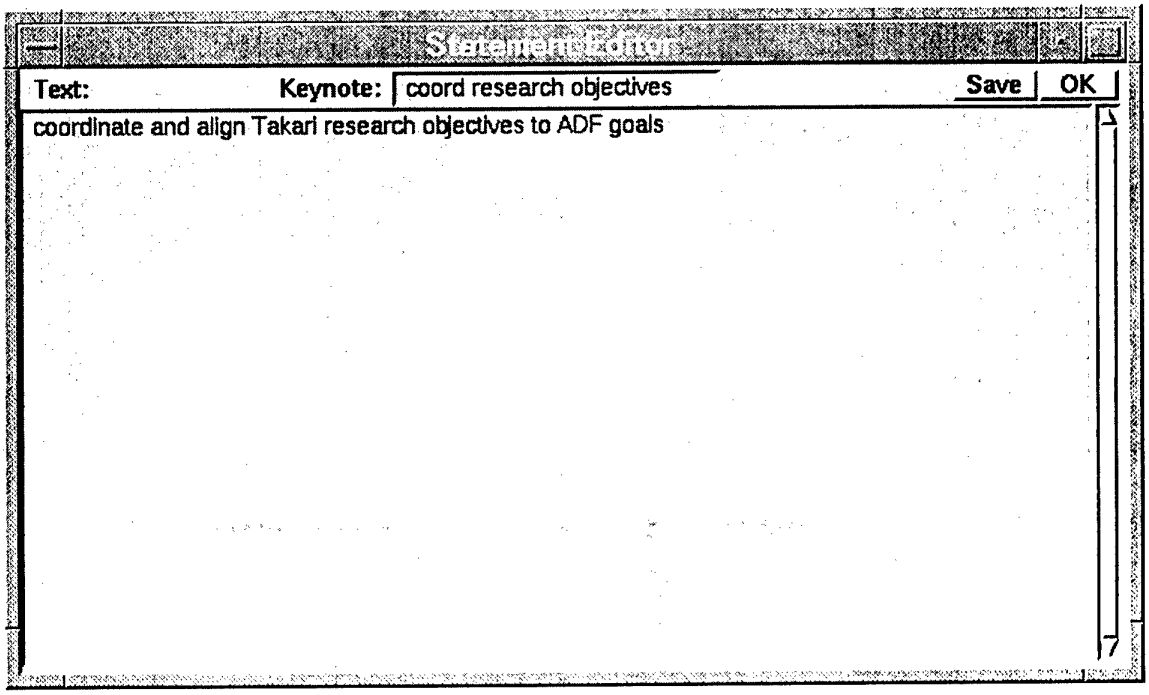

Figure 5.19 PhDStatementEditor user interface screen

Contextual information passed to PhDStatementEditor includes the statement.

PhDStatementEditor enables the following actions to be performed:

- Save - saves the text and keynote details

- OK - closes the PhDStatementEditor user interface screen

5.7.2 PhDViewStatements

PhDViewStatements enables people to construct and describe an instance of PhDPattern as shown in Figure 5.20. PhDPatterns are implemented as hypertext. The PhDViewStatements user interface screen displays a graphical representation of the pattern as a set of nodes and links, the statements that comprise these nodes, and the links between statements.

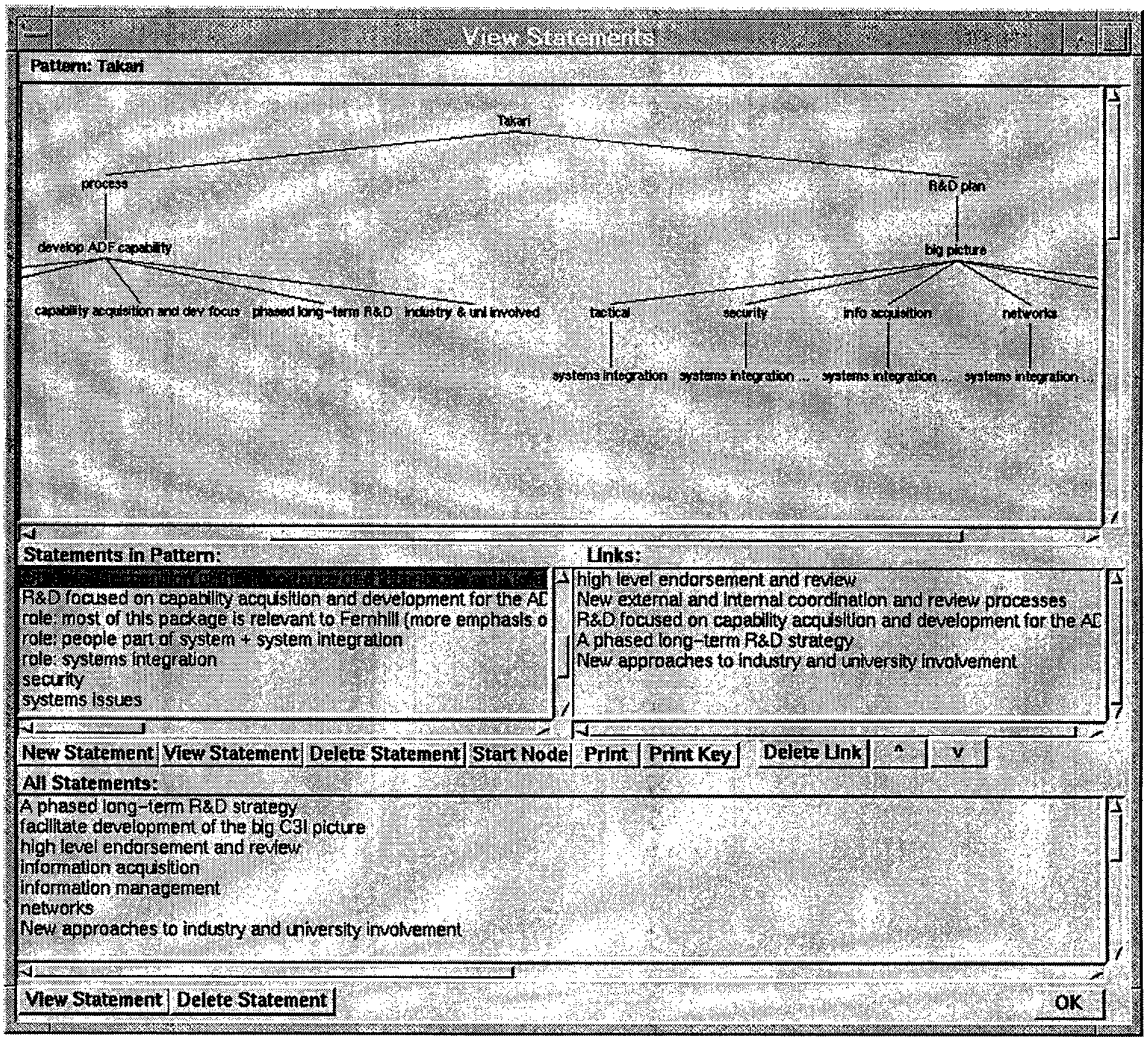

Figure 5.20 PhDViewStatements user interface screen

Contextual information passed to PhDViewStatements includes the pattern.

PhDViewStatements enables the following actions to be performed:

- New Statement - creates a new instance of PhDStatement and displays the instance in a PhDStatementEditor user interface screen.
- View Statement - displays the selected statement in a PhDStatementEditor user interface screen
- Delete Statement - deletes the selected statement and all linked statements from the pattern.
- Start Node - the selected statement is defined as the root node for the graphical representation of the pattern.
- Print - prints the pattern.
- PrintKey - prints the pattern, including keynote information for each statement.
- Delete Link - deletes the selected link for a statement.
- ^ - changes the order of links by moving the selected link "up" the list.
- v - changes the order of links by moving the selected link "down" the list.
- Drag-and-drop - the selected statement in the All Statements list is dragged to the Links list creating an instance of PhDLink to the selected statement in the Statements in a Pattern list.

5.8 Structured Information

The PhDModelListBrowser, PhDModelObjectBrowser, PhDViewModelDescription, and PhDModelBrowser user interface screens enable people to construct and reason about instances of structured information framing elements. The structured information framing elements are: PhDModel and PhDClass.

5.8.1 PhDModelListBrowser

PhDModelListBrowser enables people to construct and detail descriptive networks for models as shown in Figure 5.21. The screen display is used to construct new abstractions, and new descriptions of these abstractions, for the PhDModel framing

elements. These new abstractions and descriptions are constructed as new descriptive networks and result in the creation of new Smalltalk classes for the abstractions and descriptions.

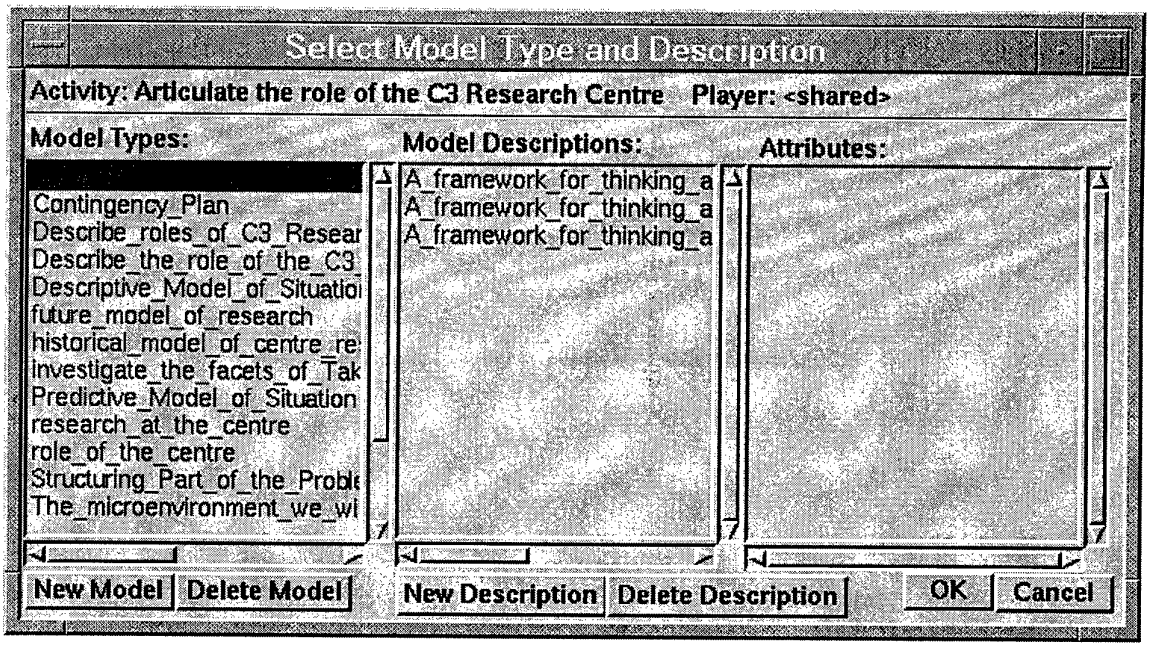

Figure 5.21 PhDModelListBrowser user interface screen

Contextual information passed to PhDModelListBrowser includes the activity and player constructing the model.

PhDModelListBrowser enables the following actions to be performed:

- New Model - creates a new abstraction of PhDModel which forms the root node of a model descriptive network.
- Delete Model - deletes the selected model and all its associated descriptions in the model's descriptive network.
- New Description - creates a new description for the selected model, thus expanding the model's descriptive network.
- Delete Description - deletes the selected description from the selected model's descriptive network.

- OK - creates a new instance of the selected model description and displays this instance in a PhDModelBrowser user interface screen.
- Cancel - closes the PhDModelListBrowser user interface.

5.8.2 PhDModelBrowser

PhDModelBrowser displays the model as a document as shown in Figure 5.22. The screen displays the attributes of the model as headings in capital letters, the concept descriptions for these attributes are displayed in brackets underneath the headings, then lists the concept hierarchies for each model attribute, and their values sequentially under each heading.

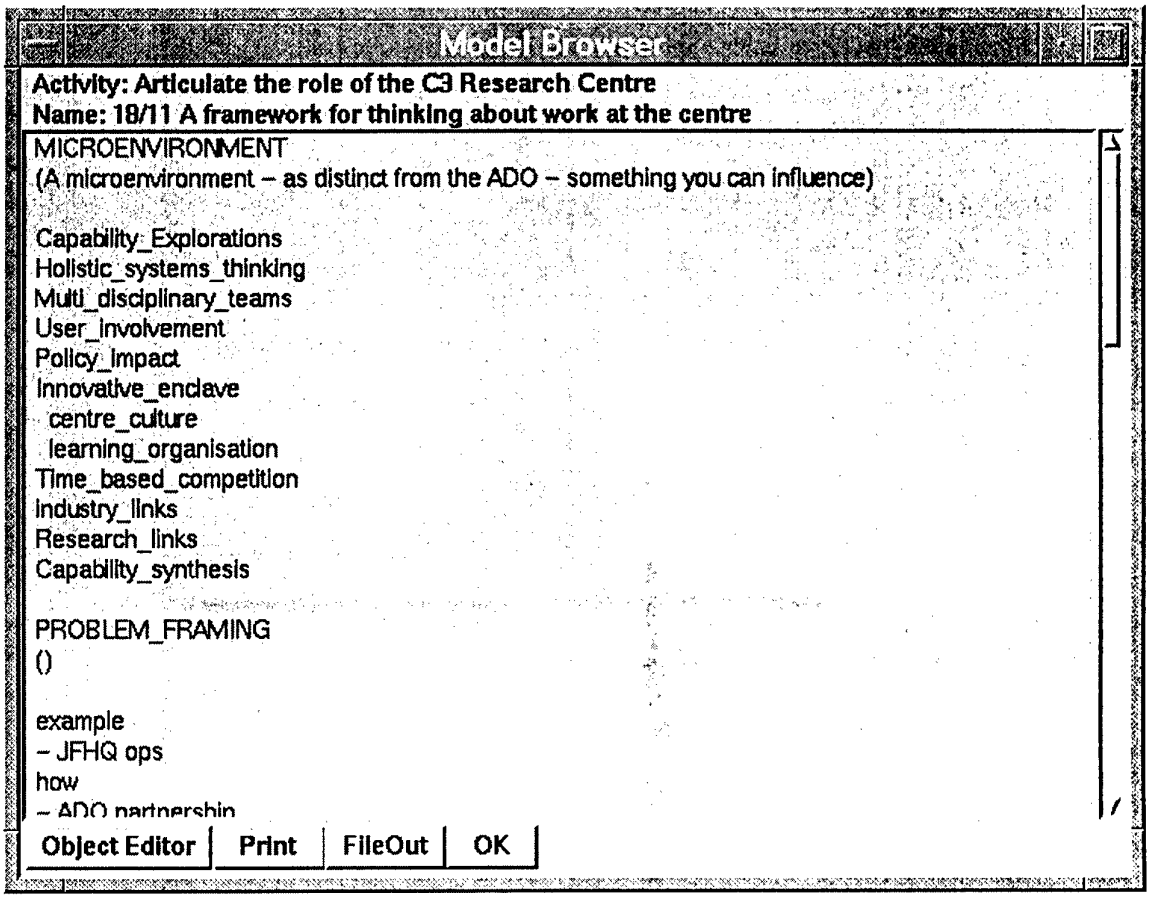

Figure 5.22 PhDModelBrowser user interface screen

Contextual information passed to PhDModelBrowser includes the model instance, activity and player.

PhDModelBrowser enables the following actions to be performed:

- ObjectEditor - enables the model attributes, concept hierarchies and values to be described in a PhDModelObjectBrowser user interface screen.
- Print - prints out the model instance as a document.
- FileOut - writes the model instance to a file as a document.
- OK - closes the PhDModelBrowser user interface screen.

5.8.3 PhDModelObjectBrowser

PhDModelObjectBrowser enables people to detail a model instance as shown in Figure 5.23. The screen display is used to define attributes as concept descriptions, develop concept hierarchies for each attribute, describe values for each attribute, and construct new abstractions and descriptions for the PhDClass framing element. These new abstractions and descriptions are constructed as new descriptive networks and result in the creation of new Smalltalk classes for the abstractions and descriptions.

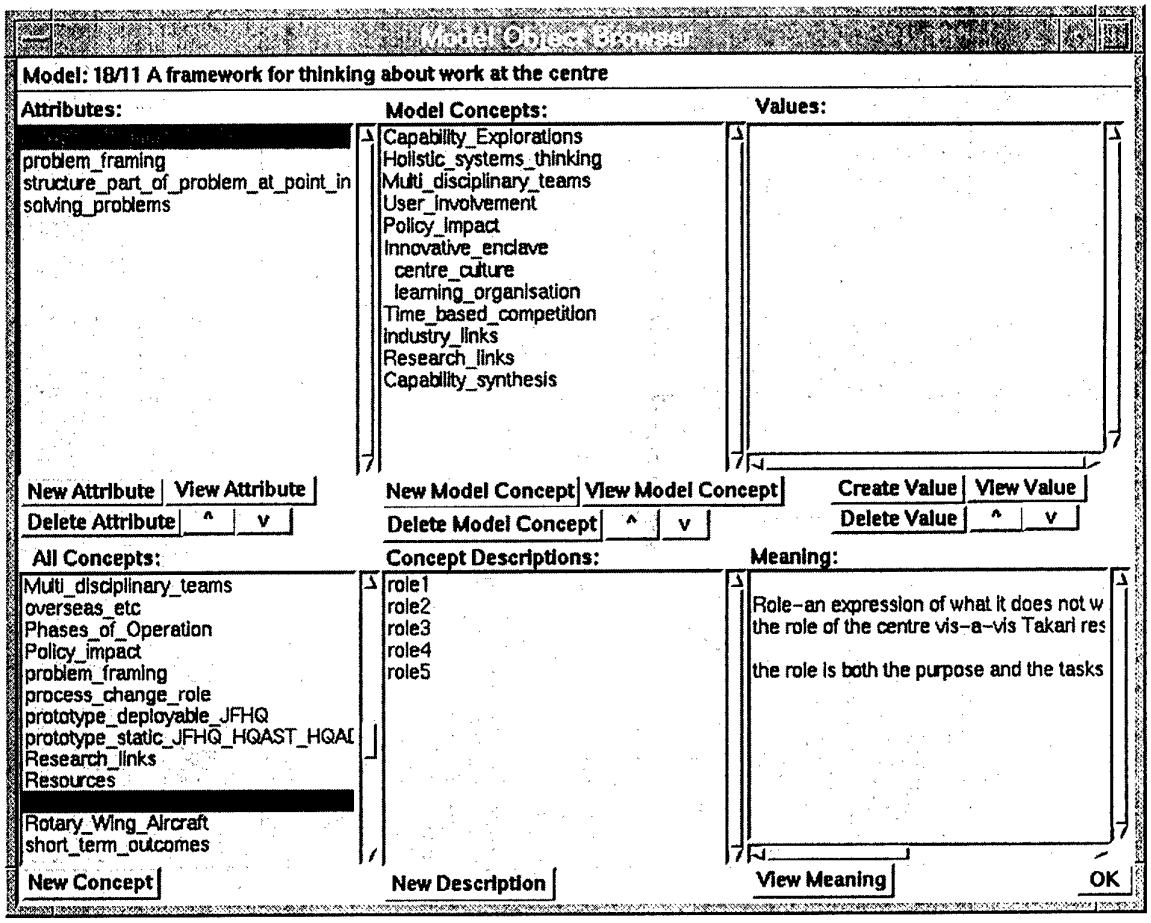

Figure 5.23 PhDModelObjectBrowser user interface screen

Contextual information passed to PhDModelObjectBrowser includes the model and the player.

PhDModelObjectBrowser enables the following actions to be performed:

- New Attribute - the selected concept description is used to create a new attribute for the model.
- View Attribute - the concept description for the selected attribute is displayed in the concept description list.
- Delete Attribute - deletes the selected attribute.
- ^ (attribute) - changes the order of attributes by moving the selected attribute "up" the list.

- V (attribute) - changes the order of attributes by moving the selected attribute "down" the list.
- New Model Concept - the selected concept description is used to create a new concept in the concept hierarchy for an attribute. The new concept is either linked hierarchically to the selected attribute or, if a model concept is selected, linked hierarchically to the selected model concept.
- View Model Concept - the concept description for the selected model concept is displayed in the concept description list.
- Delete Model Concept - deletes the selected model concept
- ^ (model concept) - changes the order of model concepts by moving the selected model concept "up" the list.
- V (model concept) - changes the order of model concepts by moving the selected model concept "down" the list.
- New Value - creates a new instance of PhDStatement for the selected attribute and displays this instance in a PhDStatementEditor user interface screen.
- View Value - the selected value is displayed in a PhDStatementEditor user interface screen.
- Delete Value - deletes the selected value.
- ^ (value) - changes the order of values by moving the selected value "up" the list.
- V (value) - changes the order of values by moving the selected value "down" the list.
- New Concept - creates a new abstraction of PhDClass which forms the root node of a concept descriptive network.
- New Description - creates a new description for the selected concept, thus expanding the concept's descriptive network.
- View Meaning - displays the text meaning for the selected concept description.
- OK - closes the PhDModelObjectBrowser user interface.

5.8.4 PhDViewModelDescriptions

PhDViewModelDescriptions is used to view all instances of models as shown in Figure 5.24. The screen displays the model instance name, the attributes and concepts for the model instance.

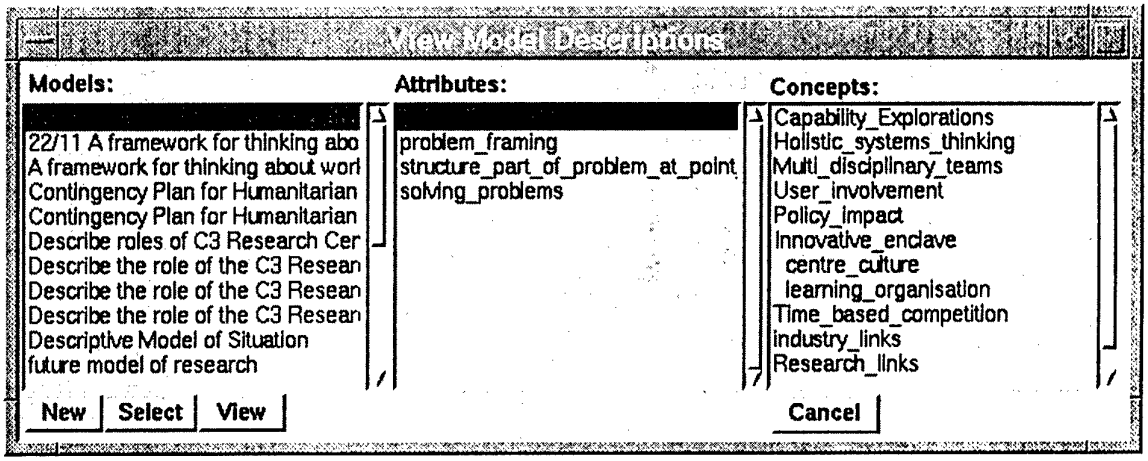

Figure 5.24 PhDViewModelDescriptions user interface screen

Contextual information passed to PhDViewModelDescriptions includes the intent for which one of the models may become an attribute.

PhDViewModelDescriptions enables the following actions to be performed:

- New - creates a new model descriptive network using the PhDModelListBrowser user interface screen.
- Select - the selected model becomes an attribute for the intent.
- View - the selected model is displayed in the PhDModelObjectBrowser user interface screen.
- Cancel - closes the PhDViewModelDescriptions user interface screen.

5.9 Summary

FRAMER currently implements three key components of the framing architecture: user interface, object model, and object storage for the accumulating pool of knowledge representations. The object model implements the sixteen framing elements as

Smalltalk classes. Pragmatically, six of these classes are represented as descriptive networks to demonstrate the utility of descriptive networks, the remaining ten classes are represented as frames. The six classes represented as descriptive networks enable people to construct new abstractions and new abstraction descriptions. These new abstractions and abstraction descriptions result in the dynamic construction of Smalltalk classes for each abstraction and abstraction description. Instantiating a descriptive network involves selecting the appropriate abstraction description and creating a new instance from it.

FRAMER consists of nineteen user interface screens that enables people to directly manipulate framing knowledge representations and navigate through the accumulating pool of knowledge representations. These user interface screens are interlinked using a computational representation of the framing elements as described in Chapter 4. The nineteen user interface screens enable people to construct framing knowledge representations by a combination of: instantiating and selecting framing elements represented as frames; construction of descriptive networks; and selecting and instantiating abstraction descriptions.

6. Case Study

> *Every wicked problem is essentially unique* --Rittel and Webber, 1973
>
> *Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly* --Rittel and Webber, 1973

This chapter describes a case study that "defines the role of the DSTO C3 Research Centre in Takari". The aim of the case study is to demonstrate how the theory of framing described in Chapter 3, the framing elements described in Chapter 4, and the implementation of these elements in FRAMER described in Chapter 5, can be used to support people framing a wicked problem.

Considerable difficulty was encountered in finding a suitable case study to employ FRAMER and demonstrate the ideas expressed in this thesis. Ideally, FRAMER would have been used by the ADF as part of their reactive planning processes at the strategic level to a crisis situation. However, this assumes that a crisis occurs at an appropriate time to fit in with the needs of a PhD program. Another alternative would be to simulate a crisis. However, one of the features of a crisis situation is the intense, sustained activity that occurs in a relatively short period of time, often in the space of one to two weeks, as people respond to events in the real-world environment. Whilst the ADF was willing to participate in a simulation, the ongoing work of the ADF staff meant that they would only be available for one to two afternoons a week, making it difficult to simulate the fluidity of framing a crisis situation. A third alternative was to support the contingency planning work conducted in the ADF. However, this activity takes a minimum of twelve to eighteen months which would have considerably lengthened the PhD program. The solution adopted was to take some of the Defence Science and Technology Organisation's (DSTO) internal planning and focus on the construction of framing knowledge representations and their use in coordinating and aligning activities within DSTO. Whilst this case study does not fully demonstrate the theory of framing as described in Chapter 3, it does show how FRAMER can be used to

construct framing knowledge representations and support people developing a shared understanding of a situation.

The chapter begins by introducing the domain and showing how the case study can be viewed as a wicked problem. An overview is presented of the actual framing process for this case study. The case study describes how people construct shared framing knowledge representations that are used to coordinate and align their activities. Each step in the framing process is described in terms of the human activity and the construction of framing knowledge representations in FRAMER. This chapter concludes with a discussion of the utility of the framing theory, framing elements and FRAMER in this case study. Appendix B documents the framing knowledge representations captured in FRAMER during the case study.

6.1 Introducing the Situation

This section introduces the case study for "defining the role of the DSTO C3 Research Centre in Takari". It starts by introducing DSTO and identifies the place of the Centre in the organisation. The Takari concept is then described. The case study focuses on how the framing knowledge representations were constructed by the "Heads of Group" social world to relate the DSTO C3 Research Centre to Takari, and how these representations were used to coordinate and align activities at the Centre. The final part of this section shows how "defining the role of the DSTO C3 Research Centre in Takari" can be viewed as a wicked problem.

6.1.1 Introducing the DSTO C3 Research Centre

The generic intent of the Australian Defence Organisation (ADO) is "defending Australia's national interests". The ADO comprises eight organisations including the army, navy, air force, and DSTO. DSTO is responsible for conducting research and development to support the ADO. DSTO is a hierarchical organisation, it consists of two laboratories, each of which is divided into a number of divisions. Each division contains a number of branches, which are divided into a number of groups. Staff in these groups may participate in one or more research tasks. These research tasks are the mechanism by which DSTO conducts research and development. Each research

task may have staff participating from one or more groups. A research task in DSTO is often unstructured in nature and can be broken down into a series of smaller pieces as people work on the research task. These smaller pieces are akin to the concept of tasks in artificial intelligence and computer science.

The DSTO C3 Research Centre was established in 1989 to conduct research into command, control and communications (C3). The Strategic Review (1993) identified C3 as one of the ADO's core intents. C3 is the process of, and the means for the exercise of authority and direction by a properly designated commander over assigned forces for the accomplishment of the commander's mission. C3 functions are performed through an arrangement of personnel, equipment, communications, facilities and procedures that are employed by a commander in planning, directing, coordinating and controlling forces and operations.

The nature of C3 requires a multi-disciplinary focus for the DSTO C3 Research Centre as shown in Figure 6.1. In the seven years that the Centre has been established, it has grown on an opportunistic basis from one to five groups, comprising about fifty staff. Each of these groups currently works to their own work plan, there is no coordinating boundary object across the Centre that integrates the work of the five groups. The Centre can be viewed as a social world, each of the groups as social worlds, and each of the research tasks is performed by a social world.

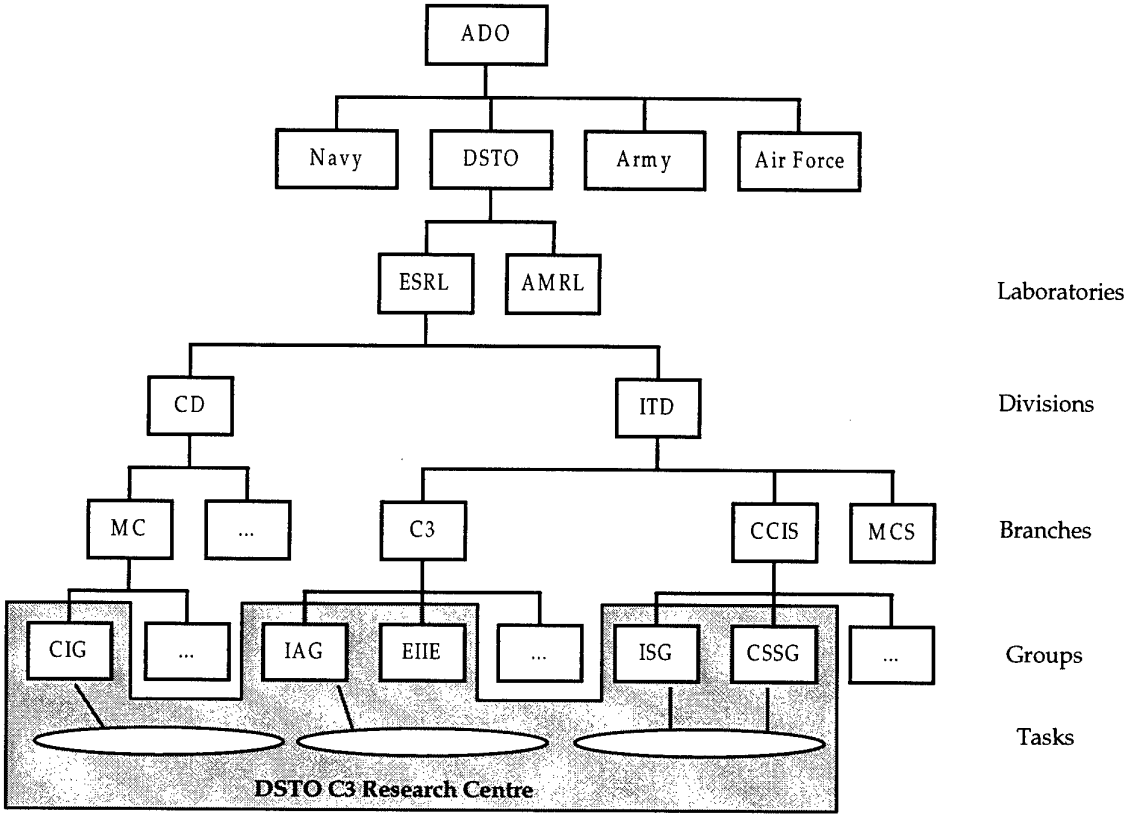

Figure 6.1 DSTO's organisation structure

An internal focus on the work performed in DSTO identifies task managers, heads of group, and research leaders as key roles in the conduct of day-to-day work. Task managers are formally responsible for managing a research task. Heads of group act as brokers between research tasks in which staff in the group are participating. Research leaders are heads of branches and are responsible for brokering between groups.

There are many social worlds in the Centre. The final social world of interest to the case study is the "Heads of Group" social world which consists of the heads of group and the research leader for the C3 Branch. This social world regularly meets to discuss Centre issues. The "Heads of Group" social world is the focal point for analysing the case study.

6.1.2 Introducing Takari

Takari is a first attempt at providing a technological description of the ADF's core intent "command, control and communications". It consists of six packages, each of which defines an area of research. These packages are: tactical, security, information acquisition, networks, information management, and systems issues. Takari is viewed as an evolving program of research with a fifteen year time horizon. As research is conducted, and the political, economic and military environments evolve, then the manifestation of the Takari research program will change.

Takari was conceived as a boundary object for coordinating and aligning the research activities of DSTO. This case study describes how people related the work at the DSTO C3 Research Centre to Takari, creating new framing knowledge representations for coordinating and aligning the disparate activities of the DSTO C3 Research Centre, and identifying opportunities for new research tasks. The activity of defining the role of the DSTO C3 Research Centre in Takari can be viewed as being external to the work being conducted at the Centre, and resulted in new insights about the work that led to the formulation of new research tasks.

6.1.3 The Situation as a Wicked Problem

The situation "defining the role of the DSTO C3 Research Centre in Takari" can be viewed as a wicked problem. The wicked characteristics include some aspects that are internal, and some external, to the Centre. Internal aspects include that each of the eight participants initially framing the situation have different backgrounds, different expertise, and are members of different social worlds at the Centre. There is currently no boundary object for coordinating and aligning the research activities of the Centre. The lack of boundary objects and the individual differences means that there is no shared descriptions of the situation.

External aspects include that each of the groups independently conceive new research tasks in collaboration with different parts of the ADF in order to develop the "command, control, and communications" capability. Any boundary object constructed for the Centre will need to evolve in response to new insights from these

research tasks, changes in the way the ADF understands and describes the core intent "command, control and communications", and changes in the descriptions of Takari.

6.2 Overview of the Framing Process for the Situation

Figure 6.2 presents an overview of the activities in the case study. The trigger for recognising the situation was a workshop attended by Centre staff that identified the need to conduct an activity to define the role of the DSTO C3 Research Centre in Takari. This activity has the aim of creating a boundary object that will coordinate and align the work conducted in the Centre.

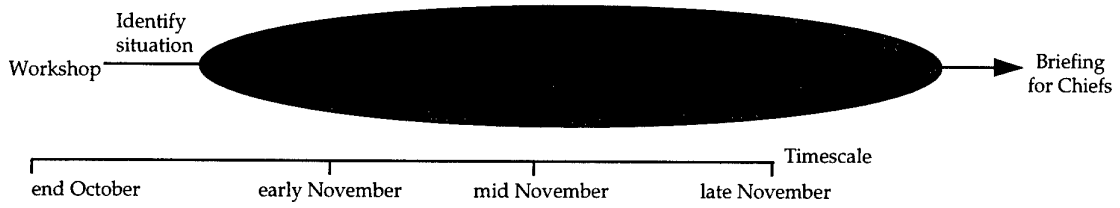

Figure 6.2 "Heads of Group" social world approval process for the case study

The "Heads of Group" social world plus two senior staff were tasked to define the role of the DSTO C3 Research Centre in Takari. Before the first meeting, each person's initial ideas were captured using FRAMER and circulated to all other participants. These ideas provided an initial "space" for reasoning about the situation.

A series of meetings were then conducted to construct framing knowledge representations that define the role of the Centre in Takari. These framing knowledge representations were communicated to the rest of the Centre social world in a brainstorming session. The brainstorming session revealed inadequacies in the framing knowledge representations for coordinating and aligning work in the Centre. This section concludes by describing the current state of this situation and its changing relationship to other work in the Centre.

6.2.1 Overview of FRAMER's use in the Situation

Each of the eight people participating in the situation are represented as PhDIndividuals in FRAMER. Each person performs a role, represented as a PhDRole, in DSTO, which is represented as a PhDOrganisation. The individuals, roles and

organisation are all defined and linked together. A new situation is constructed using the PhDSituation framing element to represent the situation. The framing intent for the situation is the core intent "command, control and communications" which is represented as a PhDCoreIntent. The situation-specific intent for the situation as described at the workshop is "Define the role of the DSTO C3 Research Centre in Takari" which is represented as a situation-specific intent.

Constructing the situation and defining the organisational context results in displaying the PhDSituationEditor user interface screen. The next step requires some human activity in the situation.

6.3 Workshop

A workshop attended by Centre staff provided the trigger for recognising the situation. The aim of the workshop was to provide an integrated focus for work conducted at the Centre. The workshop started by providing a historical description of the evolution of the Centre and the research conducted. It then moved into a discussion of the Centre's role and the core competencies of the Centre's staff. Many issues arose during these discussions that required further clarification. By the end of the workshop, a descriptive model of the concepts describing the Centre was produced, along with a set of strategies for clarifying outstanding issues. This descriptive model and set of strategies were communicated to all the Centre staff and other interested parties.

6.3.1 FRAMER's role

The workshop is represented in FRAMER as a PhDActivity for the situation. The reasoning intent for the activity is defined as a PhDReasoningIntent. This reasoning intent is described by defining a model "workshop outcomes", a set of strategies for resolving issues arising from the workshop, and these strategies are linked to activities for action. The model "workshop outcomes" contains the agreed concepts from the workshop and is represented as a PhDModel descriptive network. The strategies for resolving issues are represented as instances of PhDStrategy.

The strategy "define the role of the DSTO C3 Research Centre in Takari" is linked to a new activity "articulate the role of the DSTO C3 Research Centre in Takari". The eight people chosen to participate in this activity are represented as PhDPlayers for this activity. The set of players represents the participants in the community of practice. A "<background>" player is used to represent relevant background information from the workshop activity as models in the "define the role of the DSTO C3 Research Centre in Takari" activity.

6.4 Individual Work

FRAMER was used to capture each of the eight participant's initial attempts at describing their mental models as framing knowledge representations before the first group meeting. These representations were captured during "one-on-one" sessions between each participant and the author, and took between fifty and ninety minutes. During these sessions, the participants discussed their ideas about the role of the Centre in Takari and the author captured these ideas in FRAMER. At the completion of each session, the participant received a hardcopy of the framing knowledge representations constructed during the session in the form of patterns and models. This allowed the participant time to reflect on the framing knowledge representations, and make changes where appropriate. Several days before the first meeting, the participants' framing knowledge representations were circulated to all the other participants, allowing each participant to see the different views of the situation.

6.4.1 FRAMER's role

Each session with a participant started by attempting to capture the participant's initial ideas in an unstructured format, then structure was added to these ideas as the session progressed. The unstructured information was captured as a series of text statements, and these text statements were linked together to form patterns. The links had meaning to the participants, but were not labelled. The text statements were represented in FRAMER as PhDStatements, the links were represented as PhDLinks, and the patterns were represented as PhDPatterns.

Further structure was added to the participant's initial ideas by constructing models. These models attempted to categorise the key ideas identified by each participant. In developing these models, the participant would name the model, and then name the attributes of the model by grouping existing text statements. Where possible, the participants provided a meaning for these attributes, then either linked the existing text statements to the attributes, or constructed new text statements that encapsulated their key ideas. The models were represented as PhDModel descriptive networks, the concepts as PhDClass descriptive networks, and the models attributes were created by defining and selecting the appropriate concept description.

6.5 Heads of Group Meeting

A series of three meetings were conducted by the eight participants to define the role of the Centre in Takari. The eight individual framing knowledge representations captured before the first meeting provided the initial "space" in which the participants negotiated meaning. This section begins with a long description of what happened in each of these meetings, before discussing FRAMER's role in the process.

6.5.1 Meeting #1

Circulating the individual framing knowledge representations to all the participants enabled the participants to reflect on their own, and others, thoughts about the situation. At the start of the first meeting, Participant7[2] stated the intent for the activity of "defining the role of the DSTO C3 Research Centre in Takari". Participant7 then presented a model structure that described his view of some of the key themes that arose from the individual's framing knowledge representations as shown in Figure 6.3. The format of these models is to name the individual constructing the model, the name of the model, followed by the attributes of the model in capital letters. Under each model attribute is the meaning of the attribute in brackets, then the situated concept hierarchy for each attribute and finally any values. Figure 6.5 is an example of a model described with greater detail.

[2] The participants in this case study will be identified only by a number.

Individual: <shared>

Model: investigate the facets of Takari

TAKARI_CONCEPT

()

TAKARI_MANAGEMENT

()

TAKARI_R_AND_D

()

Figure 6.3 Initial model structure

The first hour of this meeting was spent discussing the utility of this model structure by discussing aspects of the space, and expanding the initial space by following tangential discussions. In these discussions, the participants negotiated the meaning and name of concepts that encapsulated parts of the space. For example, the participants discussed what is "Takari", what is "a capability", what is "systems thinking". Relevance was maintained by one of the participants referring back to the original intent for the activity after a tangential discussion.

After the first hour, it was apparent to all participants that the initial model structure was not useful for generating new insights in this situation. A new model structure was proposed as shown in Figure 6.4. The distinguishing feature of this model structure was that the concepts comprising the model attributes were not sourced from the space constructed from the individual's framing knowledge representations and expanded by the earlier discussions. Instead, one of the participants introduced the model structure by reinterpreting work occurring in another activity and using this work as the basis for the model structure. The value of the new model structure was that it enabled the participants to view the relationship between the DSTO C3 Research Centre and Takari in a new way through the process of "SEEING-AS".

Individual: <shared>

Model: A framework for thinking about work at the DSTO C3 Research Centre

MICROENVIRONMENT

()

PROBLEM_FRAMING

()

STRUCTURE_PART_OF_A_PROBLEM_AT_A_POINT_IN_SPACE_AND_TIM
E

()

SOLVING PROBLEMS

()

Figure 6.4 Model structure for thinking about work at the Centre

The participants decided to articulate examples at each level of the model structure to determine how well the model structure mapped onto the space that had been constructed. An example of prototyping a deployable joint force headquarters (DJFHQ) for the model attribute "problem framing" was chosen by the participants. As the participants attempted to articulate this example, discussions arose as to what the model attributes actually meant, for example, what is a microenvironment. These discussions became tangential as people tried to understand the utility of the model structure. For example, if we have a microenvironment why don't we have a macroenvironment, what is a well-structured problem, why don't we just create a new organisation structure, how many microenvironments are there, what is a system, what is C3 research? These discussions then moved into issues of process about how the participants could communicate their ideas if they couldn't clearly articulate them.

After a break, the participants agreed to work through a detailed example to see how the model structure shown in Figure 6.4 helped in articulating ideas. In the discussions that followed, the participants negotiated the meaning of the DJFHQ example in terms of the model structure by describing the model attributes, reusing concepts discussed

earlier in the meeting, creating new concepts, and moving the concepts around as the participants decided where the concepts fitted into the model structure.

The model structure was now instantiated for the DJFHQ example. The participants started asking whether the concepts were generalisable to other examples, and whether these concepts would be useful for thinking about the research being conducted in five years time. Other examples that individuals' started thinking about included Headquarters Australian Theatre (HQAST) and the Chief of the Defence Force's (CDF) information needs.

Each participant was now asked to act as a broker and describe how the work conducted in their social worlds mapped onto the model structure and description. One problem the participants found in describing their work is that the goals of their work change over time. Changing their goals results in changes to their framing concept hierarchies. For example, exercise analysis was originally viewed as "problem framing" to find out what command centres actually do. Now exercise analysis is used to keep up-to-date with work being conducted in the command centre and evaluate how prototypes developed by DSTO support the work of these command centres. Therefore, exercise analysis should probably be oriented towards "structuring problems" and "solving problems" rather than "framing problems".

At the end of the first meeting, it was decided that the exercise had been productive and that a further meeting would be held. Between these meetings, FRAMER was used to capture the model, and this model was circulated to all participants before the next meeting. FRAMER's representation of the model constructed in the first meeting is shown in Figure 6.5.

Individual: <shared>

Model: A framework for thinking about work at the C3 Research Centre

MICROENVIRONMENT

(A microenvironment - as distinct from the ADO - something you can influence)

Capability Explorations

- Systems Thinking

- multi-disciplinary

- user involvement

- policy

PROBLEM_FRAMING

()

JFHQ concepts

- study processes

- partnerships

Australian Studies

STRUCTURE_PART_OF_PROBLEM_AT_POINT_IN_SPACE_AND_TIME

()

DJFHQ concepts / HQAST / CDF vision

- systems such as JCSE, JISE, JDIS, JOTS

- Integration issues

Coalition Operations for Australia

High Reliability Organisations

SOLVING_PROBLEMS

()

Short

- C2 Support Study

- Command Centre Operation enhancement

- Image Management

- Support to current projects

- Multimodal information management
- Project Interoperability
- Security Devices
- Information Network Integration
- Civil-Military Integration
- Distributed Network Management
- Application Tools

Medium

- ROCKS
- Command Decision-Making
- Image Management
- Multimodal Information Management
- COE's
- C3I Architectures
- Security Devices
- Information Network Integration
- Civil-Military Integration
- Distributed Network Management
- Application Tools

Long

Figure 6.5 The model after the first meeting

6.5.2 Meeting #2

The second meeting commenced with Participant7 restating the intent for the activity and stating the need to construct a presentation for the rest of the Centre and for the

Chiefs. The participants were re-oriented in the activity by firstly displaying the model structure used as a generative metaphor, as shown in Figure 6.4. Then FRAMER's representation of the model produced in the first meeting, as shown in Figure 6.5, provided the starting point for the second meeting. In constructing a presentation, the participants were aiming to find two to three descriptions of each of the concepts used in the model.

Between meetings, the participants had time to reflect on the model being constructed. During the second meeting, participants introduced new concepts for each of the model attributes. Many of these new concepts came from participants brokering concepts from other social worlds in which they were engaged. For example, new concepts were brokered from work with the Australian Graduate School of Management, and from work with industry.

Meaning was negotiated in several ways during the meeting. As new concepts were suggested, the participants debated their meaning and utility in the model. Examples drawn from the work being conducted by some of the participants at the Centre were used to illustrate the meaning of a concept. If the concept was accepted, the participants then negotiated the two to three word name for the concept that would be descriptive enough for people outside the "Heads of Group" social world to be able to interpret the meaning of the concept. The members of the "Heads of Group" social world were aware that they were constructing framing knowledge representations that would need to be communicated to the Centre social world, and possibly to the Chiefs of the Divisions in DSTO.

After multiple concepts had been described for a model attribute, the participants would then negotiate whether this framing concept hierarchy reflected a useful mapping of the model attribute onto the work of the Centre. Quite often, some of these concepts would be moved to other model attributes or deleted entirely. This evaluation of framing concept hierarchies was not scheduled or coordinated. Instead, it would occur in one of three ways. Firstly, when one of the participants thought that the concepts articulating the model attribute were not capturing a useful meaning. Secondly, when a participant thought that the concepts for a model attribute were not

of the same type. Thirdly, when a participant thought that the concepts were not at the same basic-level of reasoning.

Evaluating the framing concept hierarchies could have led to a third type of negotiation where the utility of the entire model structure is discussed. The utility of the initial model structure shown in Figure 6.3 was discussed at the start of the first meeting as described in Section 6.5.1. This resulted in the creation of a new model structure for use as a generative metaphor as shown in Figure 6.4.

FRAMER's representation of the model constructed during the second meeting is shown in Figure 6.6. Towards the end of the second meeting, the participants discussed whether the model so derived assisted them in defining the role of the Centre in Takari. The participants were able to show how the current research tasks articulated for the "solving problems" model attribute could be mapped onto the six Takari packages. The role of the Centre in these packages was described as system-level synthesis. For two of the packages, information management and systems issues, the Centre would conduct deeper research into the technology issues for these packages. The participants gained confidence that the model was useful not only in describing the work of the Centre, but also in addressing the original intent of these meetings. At the conclusion of the meeting, the participants decided to have a short discussion about the model at the next Heads of Group meeting before holding a brainstorming session for the rest of the Centre's staff.

Individual: <shared>

Model: 18/11 A framework for thinking about work at the centre

MICROENVIRONMENT

(A microenvironment - as distinct from the ADO - something you can influence)

Capability_Explorations

Holistic_systems_thinking

Multi_disciplinary_teams

User_involvement

Policy_impact

Innovative_enclave

centre_culture

learning_organisation

Time_based_competition

industry_links

Research_links

Capability_synthesis

PROBLEM_FRAMING

()

example

- JFHQ ops

how

- ADO partnership

- social process

- concept development

- studies and analysis

- discovery approach

other factors

- Australian context studies (C3I and coalition)

- strategic intent

STRUCTURE_PART_OF_PROBLEM_AT_POINT_IN_SPACE_AND_TIME

(this is the level work is integrated across the centre)

Current big picture issues

- CDF needs

- prototype deployable JFHQ

- prototype static JFHQ (HQAST, HQADF)

- information / knowledge management for ADO

- COE

- current architectures for C3I

SOLVING_PROBLEMS

()

Short

- C2 Support Study

- Command Centre Operation enhancement

- Image Management

- Support to current projects

- Multimodal information management

- Project Interoperability

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Medium

- ROCKS

- Command Decision-Making

- Image Management

- Multimodal Information Management

- COE's

- C3I Architectures

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Long

Figure 6.6 The model after the second meeting

6.5.3 Meeting #3

Before the third meeting, Participant7 refined the words used in the model "18/11 A framework for thinking about work at the centre". For example, the model attribute "microenvironment" became "the microenvironment we wish to build". The third meeting was held to gain commitment from the "Heads of Group" social world for the usefulness of the model. The model produced is shown in Figure 6.7.

Individual: <shared>

Model: 22/11 A framework for thinking about work at the C3 Research Centre

THE_MICROENVIRONMENT_WE_WISH_TO_BUILD

()

Capability_Explorations

Holistic_systems_thinking

the_use_of_multi_disciplinary_teams

A_policy_impact_organisation

An_innovative_enclave

Time_based_competitiveness

Capability_synthesis

A_linked_or_networked_organisation

University

CSIRO

CSC

overseas_etc

THE_PROBLEM_FRAMING_PROCESS

(we will be adept at:)

ADO_partnership

the_social_process_for_problem_definition

concept_development

studies_and_analysis

the_discovery_approach

strategic_thinking

the_Australian_domain

STRUCTURING_PART_OF_THE_PROBLEM

(the major foci of our work for the next 1-5 years will be:)

CDF_information_needs

prototype_static_JFHQ_HQAST_HQADF_HQNORCOM

prototype_deployable_JFHQ

information_and_knowledge_management_for_ADO

THE_PORTFOLIO_OF_CURRENT_RESEARCH_TOPICS

()

Short

- C2 Support Study

- Command Centre Operation enhancement

- Image Management

- Support to current projects

- Multimodal information management

- Project Interoperability

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Medium

- ROCKS

- Command Decision-Making

- Image Management

- Multimodal Information Management

- COE's

- C3I Architectures

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management
- Application Tools
Long

Figure 6.7 The model after the third meeting

6.5.4 FRAMER's role

FRAMER was used to capture the models produced before and during each meeting. The models were represented as PhDModel descriptive networks, the concepts as PhDClass descriptive networks, the model attributes were created by defining and selecting the appropriate concept description, and the model attributes formed the basis for constructing framing concept hierarchies.

FRAMER was setup for use in the first two meetings with the aim of reifying the participation process, but not changing the way the participation process was conducted. FRAMER could not support all aspects of a meeting with eight people for a number of reasons. Firstly, the display technology was inadequate for enabling all eight participants to see the screen. Seating could have been rearranged so that all the participants had a better view of the screen, however, this would have greatly hindered the meeting dynamics because they wouldn't have been able to directly see each other. Secondly, entering, deleting and moving information around FRAMER's user interface is not as simple as doing these things on a whiteboard. Whilst the author could have driven the software to alleviate some of these problems, it would have changed the dynamics of the meeting. For these reasons, the meetings were conducted in their usual fashion, using a whiteboard as a tool for reifying discussions. FRAMER was used to capture the latest model produced during the meetings.

6.6 Centre Brainstorming

A brainstorming session was conducted with the Centre social world to assess the utility of the model produced by the "Heads of Group" social world as shown in Figure 6.7. A DSTO prototype for meeting support called GEMS (Textor and Clark 1997) was used to support the brainstorming session. The model was input into GEMS

and Centre staff were asked to input their comments about the model during the brainstorming session. An electronic discussion was held by people entering their own comments, navigating around GEMS to read other people's comments, then responding to these comments. Due to time constraints, the brainstorming session only involved an electronic discussion, there was no verbal discussion between participants.

This session resulted in many issues being raised about the meaning of concepts, the categorisation of these concepts, and the scope of these concepts. For example, one issue raised was how the work conducted for the intelligence organisation was addressed by the concepts for the model attribute "structuring part of the problem". Other issues touched on the subject of what the focus of the Centre should be. If the focus is Joint Force Headquarters (JFHQ), then aspects of current work that staff feel should be included are not included. If a more general focus is taken to allow opportunistic tasking, then it does not provide enough focus to integrate the work at the Centre.

6.7 Current Status of the Case Study

The activity of "define the role of the DSTO C3 Research Centre in Takari" has been allowed to lapse by the "Heads of Group" social world, enabling work to be performed in other situations. There are several ways of evaluating the utility of the framing knowledge representations produced during the case study. The models developed during the case study revealed holes in the Centre's existing research program. These holes provided the impetus for formulating new research tasks for the next financial year. For example, one task involves using the Experimental Command Centre facility to build an experimental DJFHQ.

Secondly, the framing knowledge representations produced during the case study were used to construct a shared understanding of the work conducted at the Centre. However, these framing knowledge representations are not being used as boundary objects to coordinate and align activities across the five groups, or to examine whether the current structure of five groups is most appropriate for the research being conducted at the Centre.

It is anticipated that further work in this activity will commence in several months. However, the starting point for this work will have changed from the initial study for several reasons. Firstly, this study has already constructed some shared framing knowledge representations. Secondly, activities being performed in other situations have further described the Takari concept, and the future possible roles of the Centre. Thirdly, the establishment and conduct of new research tasks may change the way the research program at the Centre is conceived both internally and externally. Fourthly, the membership of the "Heads of Group" social world and the Centre social world has changed, and each participant will have new experiences to integrate into the process.

6.8 Discussion of Case Study

This section explores the utility of the theory of framing described in Chapter 3, the framing elements described in Chapter 4, and the implementation of those elements in FRAMER as described in Chapter 5, for supporting the case study described in this chapter. Interesting features of the framing knowledge representations produced using FRAMER for each of the eight participants are described, focusing on the patterns produced. The utility of the theory of framing is described, focusing on the role of intents and models. The adequacy of the framing elements in creating framing knowledge representations is presented. Finally, FRAMER's role in the case study is analysed, including a comparison with GEMS.

6.8.1 Discussion of the Individual Framing Knowledge Representations Produced Using FRAMER

FRAMER was used to elicit each of the eight participant's initial mental models of the situation as framing knowledge representations. These framing knowledge representations were captured in the form of patterns and models. Analysing these representations revealed different cognitive styles for representing the situation, and that different people started reasoning about the situation in different places.

Different people use different cognitive styles for representing the situation.

Six of the participants produced top-down, or tree-type hierarchical patterns. Participant2 produced a mind-mapping pattern. Participant3 produced a dialectic

pattern. FRAMER's visualisation software employed as part of the PhDViewStatements user interface screen for displaying patterns, only displays trees or top-down hierarchies. This software supports the ability to fan-out trees, there is no support for fanning-in, which was required by some participants.

FRAMER's PhDStatement and PhDLink framing elements are flexible enough to support the different types of visualisation. However, FRAMER requires more flexible visualisation software and user interface agents that guide the user in interpreting the pattern as top-down, middle-out, dialectic, or something else.

Different people started describing their initial ideas from different places.

All the participants decomposed their initial ideas into a set of basic-level concepts that included: "the Centre", "Takari", and "the role of the Centre". The participants stated their framing activity from one of four starting points: three participants started with "Takari", three participants stated with "the role of the Centre", one participant started with "the Centre", and one participant started with a dialectical approach. These different starting places reflected the participant's expertise and experience at the Centre.

Participants1,4 and 7 were the three most senior participants and chose to start the session by exploring the concept "Takari". Having started to develop a pattern exploring the nature of Takari, these participants then alternated between further development of the nature of Takari and relating Takari to the role of the Centre.

Participants2,5, and 6 chose to start by exploring the concept "the role of the Centre". Having started to develop a pattern exploring the role of the Centre, these participants then attempted to develop the concept of Takari and map the two together.

Participant8 is a newcomer to the Centre. Choosing a starting point of "the Centre" enabled Participant8 to explore the issues from which a space could be constructed for reasoning about the role of the Centre. Participant8's patterns raised many issues about the Centre, Takari, and the relationship between the Centre and Takari. However, Participant8 was unable to find a way of resolving these issues, and was thus unable to structure the space and construct a model.

Instead of focusing on the relationships between concepts, Participant3 started by analysing the process by which Takari may evolve and then focused on the Centre's role in this process. Participant3 used a dialectic approach to reason about how future research plans are derived from the current and past activities. Participant7 described Takari as both a process and a plan, Participant3 articulated the process and showed how dynamic Takari needed to be.

Analysing the eight individual framing knowledge representations reveals discrepancies between the way participants described the three basic-level concepts. In particular, the three senior participants who started with the concept "Takari" (Participants1,4 and 7) didn't describe the concept "the Centre" at all, whereas the newest member (Participant8) extensively described this concept.

A similar phenomenon occurred in a concept mapping study of twenty eight staff who worked in a military headquarters (Noakes et al. 1996). This study revealed no common concepts across all twenty-eight staff even though all the staff had just been involved in an extensive planning activity for a crisis situation. Three staff members had unique concept maps, and one concept was shared between nineteen staff members. In the knowledge acquisition literature, Davis (1982) has reported similar problems in acquiring knowledge from multiple experts.

There are several explanations for this phenomenon including shared premises and different purposes. Coulter (1979) described how shared premises in a social setting remain unspoken, enabling people to communicate more with self-evident meanings and assumptions than with spoken conversation. The implications for knowledge engineering techniques relying on verbal protocol analysis is that these shared premises will remain tacit knowledge. As Dreyfus and Dreyfus (1986) point out, rule-based understanding is only one form of understanding. In social settings where descriptions of concepts change over time, the participants may not realise that their meanings are no longer cohesive. For example, the concept "the Centre" has evolved over seven years from describing the role of one group to describing the role of five groups from different divisions performing different types of work. An interesting followup study would investigate the degree of commonality of the concept "the

Centre" between those participants who did not describe this concept (Participants1,4 and 7).

Another explanation is that each of the participants in the study used the individual session for different purposes, exploring issues in each of their own areas of expertise. For example, Participant's issue was information overload, Participant4's the problem of fitting human factors into Takari, Participant2's the problem of having industry participation in the interoperability laboratory, Participant7's the role of a research leader in the Centre. The implications for knowledge acquisition is that whilst knowledge elicitation sessions may be about capturing an expert's core knowledge from the knowledge engineer's perspective, the experts may use these sessions as a tool for exploring the edge of their own understanding. Conducting knowledge elicitation sessions over several experts, over time, may yield quite different results as the experts continue exploring new issues on the edge of their understanding.

6.8.2 Discussion of the Theory of Framing

The theory of framing describes how intents are used to conceive situations and how people construct framing knowledge representations as boundary objects to coordinate and align work within the situation. Intents have two roles in the case study, framing the situation and keeping the participants focused. The case study illustrates how people frame situations when the existing descriptions of the framing intent are inadequate. In this case, the core intent "command, control and communications" has no description of the role of the DSTO C3 Research Centre in Takari, and does not define a social world for framing these types of situations. The existing "Heads of Group" social world forms the basis of a social world for framing the situation. The situation-specific intent is to "define the role of the DSTO C3 Research Centre in Takari". This situation-specific intent was used by the participants to keep the meeting focused following tangential discussions.

Constructing framing knowledge representations involved defining and reasoning about the utility of the model structures, assessing the utility of the framing concept hierarchies, and assessing the utility, meaning and name of a new concept.

A comparison of the models produced after each of the three meetings reveals three types of changes in the contents of the model. The model attributes are progressively renamed and defined. The framing concept hierarchies for each model attribute is articulated in more depth with different concepts. Some of the concepts move from one framing concept hierarchy to another. For example, the model attribute "PROBLEM FRAMING" includes two concepts in its framing concept hierarchy as shown in Figure 6.5 of "JFHQ concepts" and "partnerships". In the model shown in Figure 6.7, the "JFHQ concepts" concept becomes two concepts in the framing concept hierarchy for the model attribute "STRUCTURING PART OF THE PROBLEM". These concepts are "prototype static JFHQ HQAST HQADF HQNORCOM" and "prototype deployable JFHQ". The concept "partnership" becomes part of "THE MICROENVIRONMENT WE WISH TO BUILD" framing concept hierarchy. This concept is now expressed as "A linked networked organisation" with the subclasses "University", "CSIRO", "CSC", and "overseas etc".

This case study describes two ways of creating models. The first method is to invent a model structure from a space of unstructured, or semi-structured information. This technique is similar to techniques used in computer-supported collaborative work, for example, Interactive Management (Warfield and Cardenas 1994), and CM/1 (Conklin and Begeman 1989). The second method is to use an existing description as the basis for constructing framing concept hierarchies as proposed by the theory of framing in Chapter 3. In this case study, the participants found it easier to map their experience to a pre-existing description as described in Section 6.5, rather than inventing a structure as described in Section 6.4. The difficult part was finding an appropriate description to map to.

The theory of framing assumes that people can frame situations in their normal work environment. In contrast, CSCW techniques such as Interactive Management (Warfield and Cardenas 1994) deliberately place people in a carefully controlled environment where the situation context is pre-defined, the problem-solving process is handled by a facilitator, and the people can focus on producing the content to solve the problem. The relationship between the types of situations that are amenable to theory of framing approaches and those that are more amenable to Interactive Management approaches

requires further study. It is hypothesised that the theory of framing approach could be used to provide the situational context inputs to the Interactive Management approach assuming that immediate responses to the changing nature of the real-world environment were not critical factors.

6.8.3 Discussion of the Framing Elements

The framing elements described in Chapter 4 supported the construction of framing knowledge representations for the case study described in this chapter. However, deficiencies were revealed in categorising situations and activities, representing social worlds, representing organisations, and the evolution of a representation over time.

Analysing a single situation makes it simple to categorise the situation and activities occurring in this situation. However, the "messy" nature of wicked problems means that situations and activities are heavily interrelated. For example, is the workshop that triggered this case study part of the situation? One of the outcomes of reasoning about this case study is a new task that will investigate using the Experimental Command Centre as an experimental DJFHQ. Is this part of the case study's situation? Clearly activities can belong to many situations, and will be categorised in different ways by different people. Further research is required investigating the implications of an activity belonging to many situations from both an individual and an organisational perspective. This research includes exploring better ways of representing activities and situations, and better ways of displaying the relationships between activities and situations.

Social worlds are implicitly support as a set of PhDPlayers for an activity. This representation only shows the framing knowledge representations constructed by the social world for a particular activity. There is no support for showing all the activities in which the social world is currently working, or for showing any historical information about activities, or framing knowledge representations constructed. The lack of visibility of social worlds in FRAMER makes it difficult to reuse descriptions across activities. Further research is required in representing either the concept of social worlds or communities of practice, focusing on the development of shared

framing knowledge representations over time and across activities, and addressing how to support the participative aspects of people working together.

Representing organisations in terms of PhDOrganisations, PhDGenericIntents, PhDCoreIntents and PhDRoles is too simplistic. Organisations are also structured in terms of groups, teams, divisions, branches and functions. Further research is required to produce more appropriate representations that are flexible enough to cope with the development of new types of organisational structures.

A key feature of the theory of framing is the ability to evolve framing knowledge representations over time. A simplistic way of supporting this concept is simply to change the framing knowledge representation and ignore its history. However, this makes it difficult to analyse how people reason about situations and how to support the process of evolving framing knowledge representations. Further research is required investigating when a social world, and an organisation, should version a framing knowledge representation as it evolves, how long to keep these versions, and when to throw-away the framing knowledge representation. An initial hypothesis is that this versioning process is not purely algorithmic, the social world will also participate in the decision.

6.8.4 Discussion of FRAMER

FRAMER successfully demonstrated how the framing elements and theory of framing could be used to support people framing situations in the case study described in this chapter. It showed how the construction of framing knowledge representations could be supported, but failed to support all aspects of the meeting process. This section will compare FRAMER with the electronic meeting systems approach exemplified by GEMS. FRAMER's most significant problems were based on its user interface and interaction with users.

Creating and navigating framing knowledge representations requires simpler user interfaces. User interface designers have traditionally assumed well-structured knowledge representations as the basis for selecting appropriate user interface metaphors. Existing user interface metaphors do not support the dynamic construction and use of framing knowledge representations. An associated problem is the trade-off

between the size of the text and the amount of detail displayed on the screen. This trade-off limited the utility of FRAMER in supporting the meeting process because when the font size was large enough for everyone to see, too little information was displayed, but when sufficient information was displayed the font size was too small for everyone to see it.

The second limitation of the user interface is the complexity of creating models in FRAMER. A simpler way of managing the wealth of possible model descriptions, model attributes, concept descriptions, and framing concept hierarchies is required. One possible approach to both the user interface metaphor problem and the model construction problem is to explore the utility of large screen displays like Chalkboard (Stefik et al. 1987) that combine textual and graphical representations.

The framing knowledge representations constructed need to be convertible to word processing and presentation formats to facilitate their use for other purposes outside the framing process.

Heuristics for guiding the framing process would be useful. These heuristics would include some way of prompting the user for the relevance of the concept, or set of concepts for a model attribute, in terms of the intent for the activity. The underlying research question is when should a discussion be interrupted by prompting for relevance. It can be argued that tangential discussions are involved in developing the social relations between members of the social world and this enables the members of the social world to work together more effectively. So there appears to be a trade-off between developing and maintaining the social cohesiveness of the social world, and making the best use of everyone's time.

Comparing FRAMER with GEMS

GEMS was specifically used in this brainstorming session to overcome the limitations of FRAMER in the meeting process. GEMS enabled the construction and capture of a space which people used to describe issues arising from their interpretation of the model, or their interpretation of other people's responses. Capturing the entire space of the electronic discussion enabled individuals to reflect on the discussion after the session.

It is interesting to compare the electronic discussion space produced from GEMS with the individual framing knowledge representations produced from FRAMER. The process of producing individual framing knowledge representations in FRAMER enabled an individual to think more deeply about a subject, but took a lot more time. The electronic discussion approach enabled people to put down their initial ideas, then use other people's inputs to spark new ideas. This process created a broader, but shallower space than FRAMER's approach. The difficulty with the electronic discussion approach is the tendency to pursue tangential discussions, losing sight of the intent. Whereas in the meetings described in Section 6.6, tangential discussions would be brought back to the intent by a participant questioning their relevance.

Using GEMS changes the meeting process. Conversations are, at least initially, forced to occur in an electronic medium. However, holding conversations in an electronic medium poorly supports the process of constructing and reasoning about framing knowledge representations. Constructing and reasoning about framing knowledge representations occurs at three levels: the utility of the model structure in the situation; the utility of the framing concept hierarchies; and the utility, meaning, and name of a new concept. Whilst there were some discussions in GEMS about the utility and meaning of a concept, there was no discussion about the utility of the framing concept hierarchies and the model structure.

A further problem with the broadness of the electronic discussion space is the difficulty in gaining resolution and closure. Resolution and closure seems to require the process of participation. Research into meeting support systems address this problem by either using the computer system to generate an initial space then having time-out for a participation process to discuss this space. Alternatively, the system is used to capture the output of a participation process ready for use as input to the next participation process similar to the way FRAMER was used in this case study (Warfield and Cardenas 1994).

6.9 Summary

FRAMER successfully demonstrated how the framing elements and the theory of framing could be used to support people framing situations in the case study described

in this chapter. It showed how the construction of framing knowledge representations could be supported, but its ability to support the meeting process was limited by the user interface. FRAMER was used to capture each of the eight participant's framing knowledge representations which provided the basis for reasoning as a group. The representations not only modelled the situation in different ways but also represented different cognitive styles. These differences were negotiated by the participants producing shared framing knowledge representations. These shared representations identified holes in the Centre's existing research program and generated the requirement for new research tasks. In this manner, the activity of "defining the role of the DSTO C3 Research Centre in Takari" can be viewed as an external activity to the work being conducted in the Centre. The insights gained in framing this activity resulted in new research tasks which changed the alignment of the work conducted at the Centre.

7. Conclusions

> *The uncreative mind can spot wrong answers, but it takes a creative mind to spot wrong questions* --Antony Jay, Management and Machiavelli

This thesis started with the simple aim of designing computer systems that can change their behaviour as the related organisations change their behaviour. Investigating how to solve this problem revealed that whilst computer science and artificial intelligence techniques focus on problem-solving within well-structured systems, the activity of changing an organisation's behaviour occurs externally to the organisation. As a result, the focus of this thesis shifted from building computer systems that change as an organisation changes, to understanding how an organisation changes and designing computer support to facilitate these changes. The multi-disciplinary nature of this research has resulted in contributions being made to the following fields: organisational theory, cognitive science, and computer science. This chapter begins by describing the contributions to each of these fields, discusses the limitations of the work reported in this thesis, and outlines future areas of research.

7.1 The Contributions of this Thesis

There are many ways of describing organisations. The approach developed in this thesis focused on how people conceive situations in organisations, and how the process of conceiving situations could result in changing an organisation's behaviour. The contributions to organisational theory are:

- The activity of changing an organisation's behaviour is external to the organisation. This activity requires negotiation with customers, suppliers, shareholders, and other institutions in a political, economic, legal, social and regulatory framework.
- Intents are boundary objects that represent how an activity system or organisation relates to other activity systems or institutions.

- Generic intents and core intents are orthogonal views of an organisation and define a space for describing the design of an organisation.
- The ethos of an organisation describes how other institutions expect an organisation to behave, and is a subset of the space defined by an organisation's intents.
- Intents are ephemeral in nature. People reconceive intents as the real-world environment changes.
- Changing the ethos of an organisation requires negotiation with other institutions. These negotiations may result in changing the ethos of an organisation in four ways. The ethos of an organisation can expand within the space describing the organisation to include generic intents that the organisation is designed for, but is not currently performing. The remaining three ways of changing the ethos involve changing the shape of the space. The manifestations of the core intent can be redescribed through the process of "SEEING-AS". A new generic intent can be defined for the organisation, or an existing generic intent can be reconceived. A new core intent can be defined, or an existing core intent can be reconceived.

The activity of framing situations is inter-related with the activity of resolving situations. As people act in a situation they may elicit new information which changes the way the situation is framed, resulting in changes to the strategies for action. The contributions to cognitive science are:

- A theory of framing that describes how people in organisations use intents to recognise real-world events that are relevant to an organisation, conceive situations, and construct new intents that may change an organisation's behaviour.
- Descriptions of intents play three roles in the framing process. They are generative metaphors that define a way of thinking in the situation. They define a social world for initially framing the situation. They define a set of basic-level concepts which provide the basis for constructing framing knowledge representations.
- Framing involves the negotiation and construction of framing knowledge representations which consist of models, concepts, situation-specific intents, and

strategies. The process of constructing framing knowledge representations may involve finding new concepts and new descriptions of concepts.

- Framing knowledge representations are used as boundary objects to coordinate and align activities across institutions and activity systems.
- The theory of framing supports the manifestation of an intent evolving as events in the real-world environment unfold, whilst reinterpreting and reusing the framing knowledge representations.
- Reconceiving a situation is viewed differently from an organisational perspective to an individual's perspective. From an organisational perspective, the situation is simply transformed into a different type of situation in which the organisation is acting. From an individual in an organisation's perspective, reconceiving a situation often involves substantial changes to the social world framing the situation. Reconceiving a situation from an individual's perspective may mark the beginning or end of the individual's involvement in the situation.
- Current agent-oriented and decision support research focuses purely on reasoning within a system. A new paradigm is required to enable reasoning to occur externally to a system to facilitate changing a system's behaviour.

The contributions to computer science are:

- The development of a new knowledge representation technique called descriptive networks to support people negotiating and constructing framing knowledge representations. Descriptive networks separate the name of a concept from the description of a concept, enabling a concept to have many descriptions. People framing a situation can use descriptive networks to construct a new concept, or new descriptions of a concept as required.
- Three types of concept hierarchies are identified that may co-exist in any computational system that supports the framing process. The three types of concept hierarchies are: descriptive networks concept hierarchies, framing concept hierarchies, and computational concept hierarchies.

- Sixteen framing elements define a language for constructing framing knowledge representations.
- A system called FRAMER demonstrated one possible implementation of a system for aiding people framing situations that change an organisation's behaviour. FRAMER implements the descriptive networks knowledge representation technique and the sixteen framing elements.

7.2 Limitations

Fully implementing the theory of framing in FRAMER is a large and complex task. The current implementation of FRAMER has several restrictions due to only implementing sufficient functionality to support the case study described in Chapter Six. These restrictions include:

- Only six of the sixteen framing elements are implemented using the descriptive networks knowledge representation technique. This restriction simplified prototyping and testing the descriptive networks knowledge representation technique whilst still providing sufficient richness for constructing framing knowledge representations to support the case study described in Chapter Six.
- There are two side-effects from partially implementing the sixteen framing elements as descriptive networks in FRAMER. Redesigning the representations of organisation structure and activity systems is difficult in the current implementation. Secondly, there is currently no support for reusing framing knowledge representations across situations.
- FRAMER's current user interface is inadequate for supporting framing. Current user interface metaphors assume pre-defined knowledge representations and are inadequate for coping with framing knowledge representations that are defined and constructed during the framing process.

7.3 Future Research

The work reported in this thesis can be viewed as an introduction to a long-term research project investigating the relationship between organisational behaviour, how

organisations change, and how technology can be designed to facilitate and support changing an organisation's behaviour. This section documents the future directions of the research reported in this thesis, and the new questions emerging from this work.

This thesis has described the ways in which an organisation may change and how people frame situations that cause these types of changes. A more fundamental question is not how does an organisation change, but how does an organisation learn across a series of changes. Put another way, does the organisation simply reinvent its practice a number of times, or does its practice evolve to exploit changes in the real-world environment. Focusing on how an organisation learns across a series of changes raises the following research questions:

- Are social worlds an appropriate analytical unit for analysing organisations, or is the community of practice approach better? Section 2.3.3 argued that the ADF at the strategic level is more appropriately described as a set of social worlds than as communities of practice. However, one of the major advantages of the communities of practice approach is the concept of developing a shared practice over time, and over generations of members. The sub-questions then are:
  - Is it just the ADF that has no communities of practice at the strategic level, or do all organisations behave like this?
  - What are the learning strategies for transforming the social worlds at the strategic level to communities of practice?
  - What are the technology support requirements for communities of practice? Currently, the set of sixteen framing elements has no element representing either a social world or a community of practice. What sorts of things need to be represented in this framing element?
  - How are the framing knowledge representations reused when people in organisations frame new situations? Are these representations used differently when people frame situations that changes the ethos of an organisation? How can technology enable people to more effectively reuse these representations?

- Framing situations involves defining new relationships between social worlds. Can predictive models be developed exploring the stability of these relationships whilst the real-world environment continues to evolve?
- The relationship between descriptive networks and traditional artificial intelligence knowledge representation techniques requires further research, including how to map the framing knowledge representations constructed during framing to a CYC-like corporate memory.

Acknowledgements

There are many people who have contributed to the development of the ideas expressed in this thesis.

I'd like to thank my supervisors Dr Jennie Clothier and Professor Fergus O'Brien. Jennie created an environment in which I could explore new ideas, continually encouraged me to ask difficult questions, and was always available both as a mentor and friend throughout my PhD program. Fergus acted as a broker between many current and historical communities of practice, introducing me to different types of problems and different ways of doing things. Fergus and Jennie's approaches to supervision were not only complementary but synergistic. I've thoroughly enjoyed my experience thanks to their supervisory abilities.

The Defence Science and Technology Organisation (DSTO) very generously enabled my PhD studies to occur on a full-time basis in DSTO's work environment with access to many interesting domain problems in the Australian Defence Force (ADF). The richness of the stories illustrating my ideas throughout this thesis is a testament to the value of DSTO's ongoing support for this research.

Many of the ideas expressed in this thesis have benefited greatly from discussions with staff at the DSTO C3 Research Centre and our colleagues in the ADF who willingly participated in studies which led to the development of these ideas. Thanks Moira, Malathi, Brad, Terry, Warren, Richard, Richard, David, John, Thea, Marilyn, Bernard, Mike, Mark, Pin, Greg, Janet, Simon, Tony and Bruce. Thanks also to those staff who participated in the case study described in Chapter 6.

The Internet has introduced the wonderful capability to communicate with people all over the world on a wide range of issues. The learning-org mailing list is a fascinating source of new ideas and interesting viewpoints. The comp.lang.smalltalk newsgroup taught me many neat tricks for programming in Smalltalk, and solved some of my coding problems in developing FRAMER.

The single biggest difficulty I have encountered in writing this thesis was finding suitable terminology for expressing my ideas. An ongoing dialogue with Professor Bill Clancey not only helped identify new anthropological research into the social theory of learning that provided the appropriate terminology, but his IJCAI-95 workshop paper (Clancey 1997) provided the insight I needed to identify framing as the core of my thesis.

I'd like to thank my family for their support, especially my father who discovered through the course of this research that we have many common research interests despite our different academic backgrounds.

Finally, I'd like to thank Simone who has put up with me whilst I've alternated between working on my PhD and doing triathlons for the last three years. It was only during the rewrite of the second draft of my thesis that I realised how much I relied upon Simone's love and support. Thanks Simone.

Bibliography

Ackoff, R.L. 1974. *Redesigning the Future.* New York: John Wiley and Sons.

Argyris, C., and D.A. Schön. 1978. *Organisational Learning: A Theory of Action Perspective.* Reading, Massachusetts: Addison-Wesley Publishing Company.

Audi, R. 1995. *The Cambridge Dictionary of Philosophy.* Cambridge, Massachusetts: Cambridge University Press.

Bamberger, J., and D.A. Schön. 1983. Learning as Reflective Conversation with Materials: Notes from Work in Progress. *Art Education* March:68-73.

Bannon, L.J., and K. Schmidt. 1991. CSCW: Four Characters in Search of a Context. In *Studies in Computer Supported Cooperative Work,* edited by J. M. Bowers and S. D. Benford. North Holland: Elsevier Science Publishers B.V.

Benford, S. 1991. Requirements of Activity Management. In *Studies in Computer Supported Cooperative Work,* edited by J. M. Bowers and S. D. Benford. North Holland: Elsevier Science Publishers B.V.

Berger, P.L., and T. Luckman. 1969. *The Social Construction of Reality.* London: Penguin Books.

Bratman, M.E. 1987. *Intentions, Plans and Practical Reason.* Cambridge, Massachusetts: Cambridge, University Press.

Bond, A.H., and L.G. Gasser, eds. 1988. *Readings in Distributed Artificial Intelligence.* San Mateo, California: Morgan Kaufmann Publishers.

Brachman, R.J. 1985. "I Lied about the Trees", Or Defaults and Definitions in Knowledge Representation. *AI Magazine* Fall:80-93.

Burgelman, R.A. 1988. Strategy Making as a Social Learning Process: The Case of Internal Corporate Venturing. *Interfaces* 18 (3):74-85.

Chandrasekaran, B. 1986. Generic Tasks in Knowledge-Based Reasoning: High-Level Building Blocks for Expert System Design. *IEEE Expert* vol 1 (no 3):23-29.

Chaiklin, S., and J. Lave. 1993. *Understanding Practice: Perspectives on activity and context.* Cambridge, Massachusetts: Cambridge University Press.

Clancey, W.J. 1985. Heuristic Classification. *Artificial Intelligence* 27 (3):289-350.

Clancey, W.J. 1989. Viewing Knowledge Bases as Qualitative Models. *IEEE Expert* Summer:9-23.

Clancey, W. J. (1997). The conceptual nature of knowledge, situations and activity. In *Expertise in Context,* edited by P. Feltovich, R. Hoffman, and K. Ford. Menlo Park, California, The AAAI Press.

Clancey, W.J. in preparation. *Conceptual Coordination: How the Mind Orders Experience in Time.*

Clarke, A.E. 1991. Social Worlds/Arenas Theory as Organisational Theory. In *Social Organisations and Social Processes: Essays in Honour of Anselm Strauss,* edited by D. R. Maines. New York: Aldine, De Gruyter.

Compton, P., B. Kang, P. Preston, and M. Mulholland. 1993. Knowledge Acquisition without Analysis. Paper read at European Knowledge Acquisition Workshop.

Conklin, J. 1987. Hypertext: An Introduction and Survey. Computer 20 (9):17-41.

Conklin, J., and M.L. Begeman. 1989. gIBIS: A Tool for All Reasons. *Journal of the American Society for Information Science* 40 (3):200-213.

Coulter, J. 1979. The Social Construction of Mind. Totowa, NJ: Rowman and Littlefield.

Daft, R.L., and R.H. Lengel. 1986. Organisational Information Requirements, Media Richness and Structural Design. *Management Science* 32 (5):554-571.

Danielson, T., and U.P. Babatz. 1988. The AMIGO Activity Model. In *Research into Networks and Distributed Applications,* edited by R. Speth. Brussels: Elsevier Science Publishers B.V.

Davis, R. 1976. Use of Meta Level Knowledge in the Construction and Maintenance of Large Knowledge Bases. PhD, Computer Science, Stanford University.

Davis, R. 1982. Expert Systems: Where Are We? And Where Do We Go From Here? *AI Magazine* Spring:p3-22.

DeSanctis, G., and R.B. Gallupe. 1987. A Foundation for the Study of Group Decision Support Systems. *Management Science* 33 (5):589-609.

Dewar, J.A., C.H. Builder, W.M. Hix, and M.H. Levin. 1993. Assumption-Based Planning: RAND.

Dewey, J. 1938. *Logic: The Theory of Inquiry*. New York: Henry Holt and Company.

Dreyfus, H.L., and S.E. Dreyfus. 1986. Mind Over Machine. New York: The Free Press.

Engelmore, R., and T. Morgan, eds. 1988. *Blackboard Systems*. Wokingham, England: Addison-Wesley Publishing Company.

Engestrom, Y. 1993. Developmental studies of work as a testbench of activity theory: The case of primary care medical practice. In *Understanding Practice: Perspectives on activity and context*, edited by S. Chaiklin and J. Lave. Cambridge: Cmabridge University Press.

Finin, T., J. Weber, G. Wiederhold, M. Genesereth, R. Fritzson, D. McKay, J. McGuire, R. Pelavin, S. Shaprio, and C. Beck. 1994. Specification of the KQML Agent-Communication Language (Draft).

Galbraith, J. 1979. *Designing Complex Organisations*. Reading, MA: Addison-Wesley.

Gamma, E., R. Helm, R. Johnson, and J. Vlissides. 1995. Design Patterns. Reading, Massachusetts: Addison-Wesley Publishing Company.

Genesereth, M.R., and R.E. Fikes. 1992. Knowledge Interchange Format Version 3.0 Reference Manual: Stanford University.

Gentner, D., and D.R. Gentner. 1983. Flowing Waters or Teeming Crowds: Mental Models of Electricity. In *Mental Models*, edited by D. Gentner and A. L. Stevens. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Geus, A.P. De. 1988. Planning as Learning. *Harvard Business Review* March-April:70-74.

Godel, K. 1931. Uber formal unentscheidbare Satze der Principia Mathematica und verwondter Systeme I. *Monatshefte fur Mathematik und Physik* 38:173-198.

Gruber, T.R. 1992. Ontolingua: A Mechanism to Support Portable Ontologies: Knowledge Systems Laboratory, Stanford University.

Guha, R.V. 1991. Contexts: A Formalisation and Some Applications. PhD Thesis, Stanford University.

Guha, R.V., and D.B. Lenat. 1990. CYC: A Midterm Report. *AI Magazine* Fall:p32-59.

Hackathorn, R.D., and P.G.W Keen. 1981. Organisational Strategies for Computing in Decision Support Systems. MIS Quarterly 5 (3):21-26.

Hamel, G., and C.K. Prahalad. 1989. Strategic Intent. *Harvard Business Review* May-June:63-76.

Hayes-Roth, F., D. Waterman, and D. Lenat, eds. 1983. *Building Expert Systems.* Reading, Massachusetts: Addison-Wesley.

Henderson, D.A., and S.K. Card. 1986. Rooms: The Use of Multiple Virtual Workspaces to Recude Space Contention in a Window-Based Graphical User Interface. *ACM Trans. Graphics* 5 (3):211-243.

Hennessy, P. 1991. Information Domains in CSCW. In *Studies in Computer Supported Cooperative Work,* edited by J. M. Bowers and S. D. Benford. North Holland: Elsevier Science Publishers B.V.

Holyoak, K.J., and P. Thagard. 1989. Analogical Mapping by Constraint Satisfaction. *Cognitive Science* 13:295-355.

Hutchins, E. 1993. Learning to Navigate. In *Understanding Practice: Perspectives on activity and context,* edited by S. Chaiklin and J. Lave. Cambridge: Cambridge University Press.

Hutchins, E. 1995. *Cognition in the Wild.* Cambridge, Massachusetts: The MIT Press.

Jacobson, I. 1992. *Object-Oriented Software Engineering.* Wokingham, England: Addison-Wesley Publishing Company.

Jessup, L.M., and J.S. Valacich, eds. 1993. *Group Support Systems: New Perspectives.* New York: Macmillan Publishing Company.

Johnson, J.E. 1957. Wing Leader. New York: Ballantine Books.

Koestler, A. 1964. *The Act of Creation.* London: Hutchinson and Company.

Kolodner, J. 1993. *Case-Based Reasoning*. San Mateo, California: Morgan Kaufmann Publishers, Inc.

Krause, P., and D. Clark. 1993. *Representing Uncertain Knowledge*: Kluwer Academic Publishers.

Laird, J.E., A. Newell, and P.S. Rosenbloom. 1987. Soar: An Architecture for General Intelligence. *Artificial Intelligence* 33:1-64.

Lakoff, G. 1987. *Women, Fire and Dangerous Things*. Chicago: The University of Chicago Press.

Lakoff, G., and M. Johnson. 1980. *Metaphors We Live By*. Chicago: The University of Chicago Press.

Lave, J. 1988. *Cognition in Practice*. Cambridge: Cambridge, University Press.

Lave, J. 1993. The Practice of Learning. In *Understanding Practice: Perspectives on activity and context*, edited by S. Chaiklin and J. Lave. Cambridge, Massachusetts: Cambridge University Press.

Lenat, D.B. 1975. BEINGS: Knowledge as interacting experts. Paper read at Fourth International Joint Conference on Artificial Intelligence, at Tbilisi, USSR.

Lenat, D.B. 1995. Artificial Intelligence. *Scientific American* Sept:80-82.

Lenat, D.B., and J. Seely Brown. 1984. Why AM and EURISKO Appear to Work. *Artificial Intelligence* 23:p269-294.

Lenat, D.B., and E.A. Feigenbaum. 1991. On the Thresholds of Knowledge. *Artificial Intelligence* 47:p185-250.

Lenat, D.B., and R.V. Guha. 1989. *Building Large Knowledge-Based Systems*. Reading, Massachusetts: Addison-Wesley Publishing Company.

Leontev, A.N. 1978. *Activity, Consciousness, and Personality*. Englewood Cliffs, New Jersey: Prentice Hall.

Lofland, L.H. 1991. The Urban Milieu: Locales, Public Sociability, and Moral Concern. In *Social Organisations and Social Processes: Essays in Honour of Anselm Strauss*, edited by D. R. Maines. New York: Aldine, De Gruyter.

Madsen, C.M. 1989. Approaching Group Communication by Means of an Office Building Metaphor. Paper read at Proceedings First European CSCW.

Maines, D.R. 1991. *Social Organisation and Social Processes: Essays in Honour of Anselm Strauss*. New York: Aldine, de Gruyter.

Marca, D., and G. Bock, eds. 1992. *Groupware: Software for Computer-Supported Cooperative Work*. Los Alamitos, California: IEEE Computer Society Press.

March, J.G., and H.A. Simon. 1958. *Organisations*. New York: John Wiley & Sons.

McCarthy, J. 1993. Notes on Formalising Context. Paper read at Proceedings of the Thirteenth International Joint Conference on Artificial Intelligence.

Minsky, M. 1975. A Framework for Representing Knowledge. In *The Psychology of Computer Vision*, edited by P. H. Winston. New York: McGraw-Hill.

Mintzberg, H., and J.B. Quinn. 1988. *The Strategy Process - Concepts, Contexts, Cases*. Londond: Prentice Hall.

Mintzberg, H., D. Raisinghani, and A. Theoret. 1976. The Structure of 'Unstructured' Decision Processes. *Administrative Sciences Quarterly* 21:246-275.

Mitchell, M. 1993. *Analogy-Making as Perception*. Cambridge, Massachusetts: The MIT Press.

Nardi, B.A. 1996. *Context and Consciousness: Activity Theory and HCI*. Cambridge, Massachusetts: The MIT Press.

Newell, A. 1969. Heuristic Programming: Ill-structured problems. In *Progress in Operations Research III*, edited by J. Aronofsky. New York: Wiley.

Newell, A., and H.A. Simon. 1972. *Human Problem Solving*. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Newell, A. 1982. The Knowledge Level. *Artificial Intelligence* 18 (1):87-127.

Newell, A., and H.A. Simon. 1972. *Human Problem Solving*. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Noakes, B., J. Winkles, R. Davis, and T. Webb. 1996. Distributed Problem Solving and Decision Making in Military Command and Control. Paper read at The Second International Command and Control Research and Technology Symposium.

Nunamaker, J.F., A.R. Dennis, J.S. Valacich, D.R. Vogel, and J.F. George. 1991. Electronic Meeting Systems to Support Group Work. *Communications of the ACM* 34 (7):40-61.

O'Brien, F. 1997. Inverse Management Techniques. Paper read at The Third International Command and Control Research and Technology Symposium.

Ortony, A. 1993. *Metaphor and Thought*. Second ed: Cambridge University Press.

Polanyi, M. 1962. *Personal Knowledge*. Chicago: The University of Chicago Press.

Quillian, M.R. 1968. Semantic Memory. In *Semantic Information Processing*, edited by M. L. Minsky. Cambridge, Massachusetts: The MIT Press.

Rittel, H.W.J., and M.M. Webber. 1973. Dilemmas in a General Theory of Planning. *Policy Sciences* 4:155-169.

Rosch, E., C.B. Mervis, W.D. Gray, D.M. Johnson, and P. Boyes-Braem. 1976. Basic Objects in Natural Categories. *Cognitive Psychology* 8:382-439.

Rumelhart, D.E., and J.L. McClelland, eds. 1989. *Parallel Distributed Processing*. Cambridge, Massachusetts: The MIT Press.

Schank, R., and R. Abelson. 1977. *Scripts, Plans, Goals and Understanding*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Schön, D.A. 1993. Generative metaphor: A perspective on problem-setting in social policy. In *Metaphor and Thought*, edited by A. Ortony: Cambridge University Press.

Scott, W.R. 1967. *Organisations: Rational, Natural and Open Systems*. Englewood Cliffs, New Jersey: Prentice-Hall.

Senge, P.M. 1990. The Leader's New Work: Building Learning Organisations. *Sloan Management Review* Fall:7-23.

Senge, P.M. 1992. *The Fifth Discipline: The Art and Practice of the Learning Organisation*. Sydney: Random House.

Simon, H.A. 1947. *Administrative Behaviour*. New York: The Macmillan Company.

Simon, H.A. 1971. Decision-Making and Organisational Design. In *Organisation Theory*, edited by D. S. Pugh. London: Cox and Wyman Ltd.

Simon, H.A. 1973. The Structure of Ill-Structured Problems. *Artificial Intelligence* 4:181-201.

Star, S.L. 1989. The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving. In *Distributed Artificial Intelligence Vol. II*, edited by L. Gasser and M. N. Huhns. London: Pitman.

Stefik, M.J. 1980. Planning With Constraints. PhD, Computer Science, Stanford University.

Stefik, M., G. Foster, D.G. Bobrow, K. Kahn, S. Lanning, and L. Suchman. 1987. Beyond the Chalkboard: Computer Support for Collaboration and Problem Solving in Meetings. *Transactions of the ACM* 30 (1):32-47.

Strategic-Review. 1993. Strategic Review 1993. Canberra: Defence Centre.

Strauss, A. 1978. A Social World Perspective. *Studies in Symbolic Interaction* 1:119-128.

Strauss, A. 1984. Social Worlds and their Segmentation Processes. *Studies in Symbolic Interaction* 5:123-139.

Suchman, L.A. 1987. *Plans and Situated Actions*. Cambridge: Cambridge University Press.

Suczek, B., and S. Fagerhaugh. 1991. AIDS and Outreach Work. In *Social Organisations and Social Processes: Essays in Honour of Anselm Strauss*, edited by D. R. Maines. New York: Aldine, De Gruyter.

Textor, M., and T. Clark. 1997. Knowledge Management and Collaborative Work in Strategic Planning. Paper read at The Third International Command and Control Research and Technology Symposium.

Vosniadou, S., and A. Ortony, eds. 1989. *Similarity and Analogical Reasoning*. Cambridge: Cambridge University Press.

Vygotsky, L.S. 1978. *Mind in Society*. Cambridge, Massachusetts: Harvard University Press.

Wack, P. 1985a. Scenarios: shooting the rapids. *Harvard Business Review* November-December:139-150.

Wack, P. 1985b. Scenarios: uncharted waters ahead. *Harvard Business Review* September-October:73-89.

Warfield, J.N. 1973. Intent Structures. *IEEE Transactions on Systems, Man, and Cybernetics* 3 (2):133-140.

Warfield, J.N., and A.R. Cardenas. 1994. *A Handbook of Interactive Management*. Ames: Iowa State University Press.

Watzlawick, P., J.H. Weakland, and R. Fisch. 1974. *Change: Principles of Problem Formation and Problem Resolution*. New York: W.W. Norton and Company Inc.

Wenger, E. in press. *Communities of Practice: learning, meaning, and identity*. New York: Cambridge University Press.

Wilensky, R. 1980. Understanding Goal-Based Stories. New York: Garland Publishing.

Wilensky, R. 1981. Meta-Planning: Representing and Using Knowledge About Planning in Problem Solving and Natural Language Understanding. Cognitive Science 5:197-233.

Appendix A. FRAMER's Code

Installation Requirements

Software requirements:

- ParcPlace VisualWorks2.5 Development Environment. The implementation of descriptive networks requires the ability to construct Smalltalk classes dynamically which is supported in VisualWorks' development environment, but not the run-time environment.
- Tree_Browser, which is available from the University of Illinois Smalltalk archive at http://st-www.cs.uiuc.edu/ftp/pub/Smalltalk/st80_vw/Tree_Browser.st. Tree_Browser provides a graphical browser to view trees. It is used to view patterns in FRAMER and is implemented in the PhDViewStatements user interface.

Starting FRAMER requires executing the Smalltalk command **PhDWorkspace open**.

Naming Conventions

All Smalltalk classes developed for FRAMER start with the prefix "PhD". The ability to create new classes for concepts, models, and intents is supported by the following naming conventions:

- PhDo*name* - is the system name for the new concept
- PhDm*name*x - is the system name for the new description for a concept, where x is a number based on the number of descriptions created for the concept

For example, creating a new concept of "Aircraft" would result in the construction of a system class called PhDoAircraft and the first description for this concept would result in the construction of a system class called PhDmAircraft1.

- PhDt*name* - is the system name for the new model
- PhDw*name*x - is the system name for the new description for a model, where x is a number based on the number of descriptions created for the model

For example, creating a new model of "Aircraft_Transport" would result in the construction of a system class called PhDtAircraft_Transport and the first description for this model would result in the construction of a system class called PhDmAircraft_Transportation1.

- PhDg*name* - is the system name for the new generic intent
- PhDh*name*x - is the system name for the new description for a generic intent, where x is a number based on the number of descriptions created for the generic intent

For example, creating a new generic intent of "Defending_Australia" would result in the construction of a system class called PhDgDefending_Australia and the first description for this generic intent would result in the construction of a system class called PhDhDefendingAustralia.

- PhDc*name* - is the system name for the new core intent
- PhDd*name*x - is the system name for the new description for a core intent, where x is a number based on the number of descriptions created for the core intent

For example, creating a new core intent of "Transportation" would result in the construction of a system class called PhDcTransportation and the first description for this core intent would result in the construction of a system class called PhDdTransportation1.

- PhDr*name* - is the system name for the new reasoning intent
- PhDq*name*x - is the system name for the new description for a reasoning intent, where x is a number based on the number of descriptions created for the reasoning intent

For example, creating a new reasoning intent of "Investigate Explosion" would result in the construction of a system class called PhDrInvestigate_Explosion and the first description for this reasoning intent would result in the construction of a system class called PhDqInvestigate_Explosion1.

- PhDs*name* - is the system name for the new situation-specific intent

- PhDu*name*x - is the system name for the new description for a situation-specific intent, where x is a number based on the number of descriptions created for the situation-specific intent

For example, creating a new situation-specific intent of "Provide disaster relief to Rabaul" would result in the construction of a system class called PhDsProvide_disaster_relief_to_Rabaul and the first description for this situation-specific intent would result in the construction of a system class called PhDuProvide_disaster_relief_to_Rabaul.

New instances are created from a specific description for either a concept or model. Instances are NOT constructed from the concept and model class definitions. For example, creating a new instance of the class "Aircraft" requires selecting a concept description, such as PhDmAircraft1, and creating a new instance from this concept description.

Appendix B. Case Study Data

This appendix documents the data created by the people participating in the Case Study described in Chapter 6. This appendix begins by listing all the patterns produced, and then lists all the models produced.

Patterns

Individual: Participant1

Pattern: roles

roles

role of the C3 Research Centre - close to customers and therefore get better insight (what customer does; what are the customer needs - current, and anticipated by DSTO)

the role of ITD to assist the ADF in the implementation of C3I systems (broader concept)

Takari is a framework across DSTO ESRL (ignore physical location)

Goal - improve strategic and operational C3I systems of ADF

common focus is long-term. No short-term focus, each group has its own goals

more focus on short and medium term problems than Salisbury

C3 Research Centre is an interpreter between ADO and industry - DSTO share insights about ADO with industry in a way that enables industry to satisfy the perceived needs of the ADO

provision of potential solutions

develop and educate researchers (recognising the need to build a repository of expertise)

C3 Research Centre works on bits of different Takari packages

complex lines of management

Individual: Participant2

Pattern: Takari

Takari

Packages1..6

Thrusts1..n

Fernhill

Task Managers

location and customer dependent

identity of expertise

support facilities

demonstration facilities

location of participating industries

Salisbury

Task Managers

location and customer dependent

identity of expertise

support facilities

demonstration facilities

location of participating industries

Thrust coordinator

Package coordinator

Individual: Participant2

Pattern: Takari

Takari

What is Takari conceptually

Proposal for a program of research

planning basis for the ADO

will make extensive use of demonstration facilities

Takari management

Executive (planning group)

coordinators (Takari Executive and Takari Working Group)

Takari Executive - coordinate implementation of policies

working group

coordinate and align Takari research objectives to ADF goals

packages1..6

DSTO C3 Research Centre

coordinate DSTO cross-divisional activities

packages1..6

DSTO C3 Research Centre

coordinate DSTO external links for Takari

DSTO C3 Research Centre

Individual: Participant3

Pattern: A dialectic between the research of the centre and Takari research

A dialectic between the research of the centre and Takari research

Centre research

historically, a number of research tasks, unrelated to each other, no overall framework

Takari research

Ideal future - whatever unit of research is, will be directed by Takari and feedback into Takari affecting change within Takari

Individual: Participant4

Pattern: Takari

Takari

Takari packages

networks

command support and information management

C3I systems

information warfare

information acquisition

weapon systems

the centre should have a coherent C3I research program (internally consistent activities of work). But, this will cut across both Takari packages and Takari thrusts

A system level view involving people, doctrine, technology and organisational work

role: from the system's perspective (i.e. including people and organisational issues) the centre needs to identify critical components within Takari packages for which this view will give most leverage

integrating concept demonstrators as one of our major products - both short-term concept demonstrators, and longer-term as part of enabling research

role: to identify more technology areas which need to be integrated together to provide specific C3I functionality, leading to potentially different ways of doing business

Takari thrusts

the centre should have a coherent C3I research program (internally consistent activities of work). But, this will cut across both Takari packages and Takari thrusts

A system level view involving people, doctrine, technology and organisational work

role: from the system's perspective (i.e. including people and organisational issues) the centre needs to identify critical components within Takari packages for which this view will give most leverage

integrating concept demonstrators as one of our major products - both short-term concept demonstrators, and longer-term as part of enabling research

role: to identify more technology areas which need to be integrated together to provide specific C3I functionality, leading to potentially different ways of doing business

Command Support Systems

Human Factors

issue: human factors cuts across all Takari packages, whereas CSS is directly linked into one particular package (command support package)

centre: where should human factors work be directed - either a section of human factors staff (centralisation), or the human factors staff being split across projects (decentralisation)

Individual: Participant5

Pattern: role of the centre

role of the centre

role: link with industry - the centre is an ideal position to trial new ways of working between DSTO and industry

cultural/organisational innovation

role: high level strategic studies and research

studies relevant to strategic level command, operational command and deployed headquarters

issue: integrating the works across the centre - not driven by formal organisation changes, but by cultural and informing processes (people informally contribute to other tasks) - use the system as a guide, not as a set of constraints

cultural/organisational innovation

issue: does the centre have a specific role in Takari?

need to contrast the way we have worked in the past (ITD and CD), with the way we will need to work in the future as part of Takari

industry interaction

cultural/organisational innovation

defence acquisition process

cultural/organisational innovation

defence organisational structures (DSTO role in changing) - evolvement of HQAST and jointery, the impact of technology (hierarchy vs flatness)

cultural/organisational innovation

need a more dynamic way of responding to opportunities as they arise - ability to put together teams at short notice (major barrier is changing culture)

need better support for handling information overload and filtering to improve research output

cultural/organisational innovation

Individual: Participant6

Pattern: the C3 Research Centre is a focus point for C3I R&D issues for the ADO

the C3 Research Centre is a focus point for C3I R&D issues for the ADO

contribute to coordination of research in C3I

increased interaction with other parts of DSTO to facilitate coordination

change the way we coordinate tasks

role: testbed for new tasking arrangements, organisation and interaction

role in integration of wider research efforts in DSTO

if we integrate research, other people need to see the benefits - includes the researcher, users management

the integration needs to add value to the individual research

integration of research will help make us a focus-point for ADO for C3I

need to be able to call on expertise of other areas to supplement our own skills and capability to avoid spreading ourselves too thinly

need good communications and sharing of knowledge to facilitate integration

role in conducting research

we should focus on specific research areas and use other research available in DSTO where possible

should be cogniscent of work done elsewhere

research at the centre needs a strong user focus - outputs may be prototypes of simply advice or somwhere in between

needs to be responsive to changing user requirements

role in making user aware of possibilities

Centre needs to be highly visible (good PR)

The Centre needs to understand the users (not just their requirements, but the world they work in)

need to be able to demonstrate possibilities so we can educate users

users will also provide feedback to the research

Individual: Participant7

Pattern: Takari

Takari

Takari is a process

Obtaining recognition of the importance of a technology area to an ADF capability. Management of a large chunk of R&D associated with rapidly changing technology in this area for which we wish to develop an ADF capability. Australian industry will have a significant role in developing this capability

high level endorsement and review

New external and internal coordination and review processes

R&D focused on capability acquisition and development for the ADF

A phased long-term R&D strategy

New approaches to industry and university involvement

Takari is a R&D plan

facilitate development of the big C3I picture

tactical

role: systems integration

security

role: systems integration

information acquisition

role: systems integration

networks

role: systems integration

information management

role: people part of system + system integration

systems issues

role: most of this package is relevant to Fernhill (more emphasis on people issues that technology issues)

Individual: Participant8

Pattern: what is the C3 Research Centre

what is the C3 Research Centre

customers view the Centre as being integrated

customers get surprised when it isn't

should be an integrated one stop shop for the customer

customers come with C3I problem and we can either solve it or point them to Salisbury customer's don't have to deal with people from both sites for the same task

need clear lines of responsibility and authority between Salisbury and the Centre

need clear task management

personnel development - does an integrated Centre improve opportunities for Career Development? will it broaden staff skill, improve morale, satisfaction etc

role in Takari

this is the key - is there a niche for the Centre within Takari or not? I don't know, but we should not be constrained by the current structure of Takari (thrusts etc)

role of RLC3

role in management

should RLC3 be responsible for Centre Management? I would have thought so

role in scientific leadership

what is role of RLC3 in Centre in scientific leadership? In an integrated Centre it is clear, but not in the current system. Currently there is no leadership or direction for the Centre as a whole.

disadvantages

history - some people like autonomy; cultural change; must be a role for the Centre as a whole (doesn't have to be only role)

what do the Centre staff want?

Takari (and DSTO) are big enough and flexible enough

do the people in the Centre want a MORE integrated approach - if so, make it so (doesn't ahve to be totally integrated, its a spectrum)

Individual: Participant8

Pattern: Takari!

Takari!

what does it mean?

many do not know what it means for them. still planning the details of the R&D plan so some lack of clarity. Takari management and leadership conflicts with current structure and organisation. coordiantion between Divisions and Takari packages needs to improve. who is responsible for Takari? - not clear. all this makes it very difficult to determine whether there is a niche for the Centre or not

role as a C3 integrator. see this as more of a high level view of C3 e.g. eadvising on the C3 system as a whole and how it should be developed. but where does this fit into Takari? currently package and thrust structure would not lead to a separate role for the Centre - cut across the groups in the Centre. can have other roles in the Centre which do not require an integrated Centre

why? Location. knowledge of the C2 processes. knowledge of the capability development process

can Takari structure be changed? shouldn't be seen as inviolate. if we believe there is a role for the Centre then how can we adapt Takari to fit it? Takari structure is but one way of structuring our R&D to reduce overlap

Not all DSTO R&D should be part of Takari. Not all the Centre's R&D should be part of Takari. The C2SS isn't - no one would say we shouldn't be doing it. What Package in Takari is advising on the development of the ADF C2 system as a whole? Where would work on a C2 Master Plan fit in? (or other policy advising). Don't think there is an appropriate package. Structure isn't oriented towards ADF outcomes but an architectural approach to C3I

Models

Individual: <background>

Model: workshop outcomes

VALUES

()

Agree that activities at the DSTO C3 Research Centre are part of Takari

Agree that we should articulate more clearly the specific role of the C3 Research Centre in Takari

Agree that our activities at the C3 Research Centre should be strongly integrated with the activities of our co-workers including: DSTO colleagues, other ADO colleagues, academia, industry partners

Agree that we have a C3I focus. By this we mean that we take the holistic or system view where the system includes the people rather than the component view

Agree that there are benefits from the collocation of research groups at Fernhill and from the groups working interactively

Agree that we should explore innovative ways of working - both internally and externally

Agree to develop specific actions based on the above outcomes

Agree to explore further the appropriateness of the Centre name

Individual: Participant1

Model: Describe the role of the C3 Research Centre

FACILITATOR

(how we discharge our responsibilities)

improve C3I systems in the ADO

gain customer insight by being close to the customer

act as an interpreter of the ADO for industry

CURRENT_ORGANISATION

(how we are currently organised)

DSTO C3 Research Centre is an integrated part of ITD rather than a separate coherent part of ESRL

C3 Research Centre works on bits of different Takari packages

complex lines of management

Individual: Participant2

Model: Describe the role of the C3 Research Centre in Takari

ROLE

(Role-an expression of what it does not what distinguishes it. Roles apply only within a package)

coordinate and align Takari research objectives to ADF goals

coordinate DSTO cross-divisional Takari activities

coordinate DSTO external links for Takari

provision of C3I R&D issues

Individual: Participant3

Model: historical model of centre research

DRIVERS_FOR_RESEARCH

(competing factors taht lead to a research direction)

personal interests

interests of manager

interesting ideas of research in wider world

other stakeholders including research leaders interests, colleagues, customer

Individual: Participant3

Model: future model of research

DRIVERS_FOR_RESEARCH

(competing factors that lead to a research direction)

Takari directions

personal interests

other stakeholders including your manager, colleagues, research leader, customers and opportunities

Individual: Participant3

Model: transition model of research

ROLE

(the role of the centre vis-a-vis Takari research)

the centre will contribute to Takari research and follow its directions, but it will also change the future of Takari research. Sometimes the centre is driven by Takari, sometimes Takari will be driven by the centre

MODEL_OF_RESEARCH

()

A dialectic between the research of the centre and Takari research

A progressive, ever-changing set of parallel, interlinked wave-fronts. An example from biology is the evolution of life-forms, sometimes its competing, sometimes complementary, and sometimes one extinguishes another

The Centre will be driving a wave-fraont that derives from the Takari wave-front and changes future Takari wave-fronts

Model of research provides the way of moving from the historical to the future through the transitional

INFLUENCES_ON_RESEARCH

(factors that influence research directions)

Takari

research in the centre is also influenced by research elsewhere in the world that has different research goals to Takari

CHARACTERISTIC

(a quality)

a move from isolationist research to complementary research

DRIVERS_FOR_RESEARCH

(competing factors taht lead to a research direction)

an increasing focus on the Takari directions for research and a phaing out and/or redirecting of current tasks

Individual: Participant4

Model: research at the centre

GOALS

(A goal is a vision for where you want to go)

the centre should have a coherent C3I research program (internally consistent activities of work). But, this will cut across both Takari packages and Takari thrusts

A system level view involving people, doctrine, technology and organisational work

Integrating concept demonstrators as one of our major products - both short-term concept demonstrators, and longer-term as part of enabling research

FACTORS

(a factor is an issue)

how we organise ourselves to accommodate both functional and discipline ways of working e.g. ehwer should human factors work be directed - either a section of human factors staff (centralisation), or the human factors staff being split between projects (decentralisation)

some thrusts map neatly onto packages where other thrusts don't e.g. human factors cuts across all Takari packages, whereas CSS is directly linked into one particular package (command support package)

need to identify critical C3I issues for the centre to address (system issues and critical C3I components)

staff and resources

interface with customer

Individual: Participant5

Model: role of the centre

ROLE

()

role: high level strategic studies and research

CHARACTER

(the distinctive description of what we are and what we do and how we do it)

cultural/organisational innovation

Individual: Participant6

Model: Describe the role of the C3 Research Centre

ISSUES

()

does the centre have a role outside Takari?

improved awareness of research, tasking, skills

ROLE

(the role is both the purpose and the tasks)

the C3 Research Centre is a focus point for C3I R&D issues for the ADO

role in conducting research

role in integration of wider research efforts in DSTO

role in making users aware of possibilities

contribute to coordination of research in C3I

role: testbed for new tasking arrangements, organisation and interaction

Individual: Participant7

Model: Describe roles of C3 Research Centre in Takari

ROLE

()

Systems level thinking for Takari

understanding the thinking/processes of the strategic level of command

Process change role

strong link to client

ownership of the big C3I picture

ownership of the C3I system-user interface

systems integration role (tactical, security, information acquisition, and network packages)

role in information management package is people part of system + system integration

role in Systems issues package of Centre will be very important (more people-driven than technology-driven)

SYSTEMS_LEVEL_THINKING

()

Need to understand the C3I system (system architecture, processes, structures, skills/roles) across the strategic, operational and tactical levels

Need to understand how people use the system

Need to understand how we would build such a system

synthesise new systems to address deficiencies of existing systems

Need to understand how we can influence the construction of the system

note: system not components

UNDERSTAND_STRATEGIC_COMMAND

()

PROCESS_CHANGE_ROLE

()

R&D->Development->Procurement->Use and Support

STRONG_LINK_TO_CLIENT

()

Individual: <shared>

Model: investigate the facets of Takari

TAKARI_CONCEPT

()

TAKARI_MANAGEMENT

()

TAKARI_R_AND_D

()

Individual: <shared>

Model: A framework for thinking about work at the C3 Research Centre

MICROENVIRONMENT

(A microenvironment - as distinct from the ADO - something you can influence)

Capability Explorations

- Systems Thinking

- multi-disciplinary

- user involvement

- policy

PROBLEM_FRAMING

()

JFHQ concepts

- study processes

- partnerships

Australian Studies

STRUCTURE_PART_OF_PROBLEM_AT_POINT_IN_SPACE_AND_TIME

()

DJFHQ concepts / HQAST / CDF vision

- systems such as JCSE, JISE, JDIS, JOTS

- Integration issues

Coalition Operations for Australia

High Reliability Organisations

SOLVING_PROBLEMS

()

Short

- C2 Support Study

- Command Centre Operation enhancement

- Image Management

- Support to current projects

- Multimodal information management

- Project Interoperability

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Medium

- ROCKS

- Command Decision-Making

- Image Management

- Multimodal Information Management

- COE's

- C3I Architectures

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Long

Individual: <shared>

Model: 18/11 A framework for thinking about work at the centre

MICROENVIRONMENT

(A microenvironment - as distinct from the ADO - something you can influence)

Capability_Explorations

Holistic_systems_thinking

Multi_disciplinary_teams

User_involvement

Policy_impact

Innovative_enclave

centre_culture

learning_organisation

Time_based_competition

industry_links

Research_links

Capability_synthesis

PROBLEM_FRAMING

()

example

- JFHQ ops

how

- ADO partnership

- social process

- concept development

- studies and analysis

- discovery approach

other factors

- Australian context studies (C3I and coalition)

- strategic intent

STRUCTURE_PART_OF_PROBLEM_AT_POINT_IN_SPACE_AND_TIME

(this is the level work is integrated across the centre)

Current big picture issues

- CDF needs

- prototype deployable JFHQ

- prototype static JFHQ (HQAST, HQADF)

- information / knowledge management for ADO

- COE

- current architectures for C3I

SOLVING_PROBLEMS

()

Short

- C2 Support Study

- Command Centre Operation enhancement

- Image Management

- Support to current projects

- Multimodal information management

- Project Interoperability

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Medium

- ROCKS

- Command Decision-Making

- Image Management

- Multimodal Information Management

- COE's

- C3I Architectures

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Long

Individual: <shared>

Model: 22/11 A framework for thinking about work at the C3 Research Centre

THE_MICROENVIRONMENT_WE_WISH_TO_BUILD

()

Capability_Explorations

Holistic_systems_thinking

the_use_of_multi_disciplinary_teams

A_policy_impact_organisation

An_innovative_enclave

Time_based_competitiveness

Capability_synthesis

A_linked_or_networked_organisation

University

CSIRO

CSC

overseas_etc

THE_PROBLEM_FRAMING_PROCESS

(we will be adept at:)

ADO_partnership

the_social_process_for_problem_definition

concept_development

studies_and_analysis

the_discovery_approach

strategic_thinking

the_Australian_domain

STRUCTURING_PART_OF_THE_PROBLEM

(the major foci of our work for the next 1-5 years will be:)

CDF_information_needs

prototype_static_JFHQ_HQAST_HQADF_HQNORCOM

prototype_deployable_JFHQ

information_and_knowledge_management_for_ADO

THE_PORTFOLIO_OF_CURRENT_RESEARCH_TOPICS

()

Short

- C2 Support Study

- Command Centre Operation enhancement

- Image Management

- Support to current projects

- Multimodal information management

- Project Interoperability

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Medium

- ROCKS

- Command Decision-Making

- Image Management

- Multimodal Information Management

- COE's

- C3I Architectures

- Security Devices

- Information Network Integration

- Civil-Military Integration

- Distributed Network Management

- Application Tools

Long

Framing: Supporting Change for a System as an External Activity

John O'Neill

DISTRIBUTION LIST

Defence Science and Technology Organisation

Chief Defence Scientist FAS Science Policy AS Science Corporate Management	1 shared copy
Director General Science Policy Development	
Counsellor Defence Science, London	(Doc Data Sheet)
Counsellor Defence Science, Washington	(Doc Data Sheet)
Scientific Adviser to MRDC Thailand	(Doc Data Sheet)
Director General Scientific Advisers and Trials/Scientific Adviser Policy and Command	(shared copy)
Navy Scientific Adviser	(Doc Data Sheet)
Scientific Adviser - Army	(Doc Data Sheet)
Air Force Scientific Adviser	
Director Trials	
Director, Aeronautical and Maritime Research Laboratory	

Electronics and Surveillance Research Laboratory

Director, Electronics and Surveillance Research Laboratory	1
Chief, Information Technology Division	1
Research Leader Command, Control and Communications	1
Research Leader Command & Control and Intelligence Systems	1
Research Leader Military Computing Systems	1
Head, Information Architectures Group	1
Head, Information Warfare Studies Group	1
Head, Trusted Computer Systems Group	1
Head, Advanced Computer Capabilities Group	1
Head, Software Systems Engineering Group	1
Head, Intelligence Systems Group	1
Head, Command Support Systems Group	1
Head, Human Systems Integration Group	1
Head, Information Management and Fusion Group	1
Head, C3I Operational Analysis Group	1
Head, Systems Simulation and Assessment Group	1
Mr Greg Marsh	1
Dr Richard Davis	1
Dr Terry Webb	1
Dr Tony Dekker	1
Author (John O'Neill)	10

DSTO Library

Library Fishermens Bend	1
Library Maribyrnong	1
Library Salisbury	2
Australian Archives	1

Library, MOD, Pyrmont	Doc Data sheet
Capability Development Division	
Director General Maritime Development	Doc Data Sheet
Director General Land Development	Doc Data Sheet
Director General Air Development	Doc Data Sheet
Director General C3I Development	1
Corporate Support Program (libraries)	
OIC TRS, Defence Regional Library, Canberra	1
Officer in Charge, Document Exchange Centre (DEC)	1
US Defence Technical Information Center	2
UK Defence Research Information Centre	2
Canada Defence Scientific Information Service	1
NZ Defence Information Centre	1
National Library of Australia	1
UNIVERSITIES AND COLLEGES	
Australian Defence Force Academy Library	1
Professor Janet Aisbett & Dr Greg Gibbon, University of Newcastle	1
Professor Paul Compton, University of New South Wales	1
ABSTRACTING AND INFORMATION ORGANISATIONS	
INSPEC: Acquisitions Section Institution of Electrical Engineers	1
Library, Chemical Abstracts Reference Service	1
Engineering Societies Library, US	1
Materials Information, Cambridge Scientific Abstracts, US	1
Documents Librarian, The Center for Research Libraries, US	1
Other Organisations	
Australian Defence Force Warfare Centre	1
Joint Services Staff College	1
Strategic Studies Centre	1
Air Power Studies Centre	1
Australian College of Defence Strategic Studies	1
Professor Bill Clancey, Institute for Research on Learning, 66 Willow Place, Menlo Park, CA 94025-3601, USA	1
SPARES	5
Total number of copies:	**65**

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION
DOCUMENT CONTROL DATA

1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)

2. TITLE

Framing: Supporting Change for a System as an External Activity

3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION)

Document	(U)
Title	(U)
Abstract	(U)

4. AUTHOR(S)

John O'Neill

5. CORPORATE AUTHOR

Electronics and Surveillance Research Laboratory
PO Box 1500
Salisbury SA 5108 Australia

6a. DSTO NUMBER	6b. AR NUMBER	6c. TYPE OF REPORT	7. DOCUMENT DATE
DSTO-RR-0127	AR-010-~~255~~ 461	Research Report	March 1998

8. FILE NUMBER	9. TASK NUMBER	10. TASK SPONSOR	11. NO. OF PAGES	12. NO. OF REFERENCES
N9505/15/37	ADF94/150	DGC3ID	230	118

13. DOWNGRADING/DELIMITING INSTRUCTIONS

N/A

14. RELEASE AUTHORITY

Chief, Information Technology Division

15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT

Approved for public release

OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE CENTRE, DIS NETWORK OFFICE, DEPT OF DEFENCE, CAMPBELL PARK OFFICES, CANBERRA ACT 2600

16. DELIBERATE ANNOUNCEMENT

No Limitations

17. CASUAL ANNOUNCEMENT Yes

18. DEFTEST DESCRIPTORS

Framing
Strategic planning
Computer programs
Military planning

19. ABSTRACT

This thesis demonstrates how computer systems can aid people in organisations conceiving situations that change an organisation's behaviour. A theory of framing is proposed that describes how people in organisations use intents to recognise real-world events that are relevant to an organisation, conceive situations, and through a negotiation process construct new intents that can change an organisation's behaviour. A system called FRAMER was developed to demonstrate how the theory of framing can be used to aid people framing situations that change an organisation's behaviour. Two case studies are used to illustrate the utility of the theory of framing: one drawn from the strategic and operational planning required for an actual ADF operation, the second drawn from some of DSTO's internal planning.